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ABBREVIATIONS. — D. = Discussion; I. = Illustrated.
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PURE WATER AND ITS RELATION TO HEALTH.

BY J. W. ELLMS.*

[Read before Detroit Engineering Society, November 17, 1911.]

THOSE phases of public hygiene which have to do with the supply of drinking water and the disposal of sewage are among the most important which affect the individual and the community as a whole. The problems which they present are those of engineering, chemistry and biology. Their successful solution is only possible by the application of the principles which underlie these several branches of knowledge. With our present conception of the causation of many diseases, it has been natural to conclude that one avenue for infection might be found in our drinking water. Both direct and circumstantial evidence have amply confirmed this conclusion. The increasing pollution of natural sources of public water supply has made imperative the purification of our drinking water wherever contamination is suspected.

If we commence our discussion of this subject by stating what modern science defines as potable water, we may avoid some confusion and at once gain a standpoint from which the whole subject may be viewed in a rational manner.

To say that a potable water is one that is suitable for drinking does not enlighten us very much, for the popular conception of suitability is about as varied as the different kinds of liquid which are pumped through the pipe lines of our municipalities

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and called drinking water. Even if we disregard the problem of public water supplies and betake ourselves in imagination to the "old oaken bucket," which the poet informs us was "dripping with coolness," the modern bacteriologist is liable to spoil our illusion by remarking that it was probably dripping with typhoid-fever germs at the same time.

Modern science, therefore, demands that a potable water shall have at least two qualifications before it can be regarded as suitable for drinking.

1. It must be attractive in appearance, without odor and practically without taste.

2. It must be free from those substances which induce or actually cause disease.

The first property is one on which we can all agree without much trouble. A water turbid with sediment or colored with vegetable matter is offensive to the eye, no matter how harmless from a sanitary point of view. Waters which have an odor or a pronounced taste, we will not drink, even if there is no possibility of their inducing or causing disease. Our senses in this matter are a pretty fair guide to what is really suitable to drink.

The second quality of a potable water, however, is really more important than the first. A water may be unpalatable and offend all of the senses, and yet it may or may not be actually capable of causing disease. In fact, the modern science of bacteriology has clearly demonstrated that a drinking water may be ideal as to appearance, sense of smell and taste, and yet be as truly a poison as a solution of corrosive sublimate. To die of typhoid fever or cholera, after a more or less prolonged illness, is perhaps less dramatic than to drop dead on the spot after drinking a solution of some poison, but the result is just the same; and moreover, the unfortunate person who succumbs to disease may leave a trail of infection behind him which is a menace to all who come in contact with it.

Opinions unsupported by statistical evidence have but little weight, and while figures are proverbially dry and uninteresting, I have endeavored to collect a few which, I believe, will support the preceding statements and which you may find of some interest.

The danger of infection from drinking water is dependent upon two facts, — (1) the possibility of pathogenic organisms entering the water supply, and (2) their ability to propagate or to maintain their vitality after entrance under probably somewhat abnormal conditions. The first danger nobody will dis-

pute exists. Disposal of sewage and manufacturing wastes by dilution with water and their discharge into rivers and lakes is our most common method of getting rid of offensive material. Yet these same streams and lakes furnish, and in most cases must continue to furnish, the water needed for our public supplies. Sometimes we drink our own diluted sewage, but more often we pass it on, if possible, to the next community. Nobody can deny, therefore, that abundant opportunity exists for infection of drinking water; and no one, who has made even a most superficial examination of the sanitary conditions surrounding the sources of the larger number of our public water supplies, would claim that they are not all polluted to a greater or less degree.

Water-Borne Diseases.

Probably most of the diseases transmitted by drinking water affect the alimentary canal, and more commonly that part of it included in the intestines. There are several of this class of diseases which have specifically been shown to have been disseminated through the agency of drinking water. Two of these diseases, namely, cholera and typhoid fever, have at times made fearful inroads upon the human race, and the toll which they still demand is enormous. Certain other diseases of the digestive system have also been attributed to impure drinking water, with fairly good proof of the claim. But the circumstantial as well as the direct evidence that cholera and typhoid fever are water-borne diseases has been accepted as conclusive in a number of thoroughly investigated epidemics.

Cholera has never as yet gained a permanent foothold in this country. However, eight epidemics of cholera have occurred in the United States since 1832, the last one being in 1873. We every now and then are warned that suspected cases have arrived at some of our seaports, and are reminded that eternal vigilance is the price of immunity.

The almost classic illustration of how water supplies may, if polluted, infect whole communities is shown by the Hamburg epidemic of cholera in 1892. The city was using unfiltered water from the River Elbe, which was contaminated by the sewage of over 800 000 people. During the fall of 1892, 17 000 cases developed, resulting in 8 600 deaths. Altona, nominally a suburb of Hamburg, although really a part of it, was supplied with filtered river water. Only five hundred cases developed in Altona, resulting in three hundred deaths. In fact, wherever

the drinking-water supply was either filtered or obtained from some source other than the river, few or no cases resulted.

Another illustration of how a polluted water supply produced a severe epidemic of cholera in London in 1854 is worth citing. One of the water companies of the city drew its supply from the contaminated water of the Thames. Amongst its consumers the death-rate from cholera was 1 540 per 100 000 of population; while in a neighboring district supplied with unpolluted water, the death-rate was only 170 per 100 000. Again, in 1866, by the temporary substitution of unfiltered water for filtered water in the district supplied by the East London Water Company, the death of 3 400 persons from cholera was caused, while other parts of London were entirely free from the disease.

If we turn now to the disease which is endemic in this country, and trace a few of the epidemics of typhoid fever, I believe that we shall prove conclusively that polluted drinking water is a standing menace to every community that is obliged to use it. The following table includes some of the epidemics of typhoid fever which investigators have satisfied themselves were due to polluted drinking water.

Place.	Year.	Population.	Number of Cases.	Number of Deaths.
Caterham, England........	1879	5 000	352	21
Plymouth, Pa...............	1885	8 000	1 104	114
Ithaca, N. Y..............	1903	13 000	1 300	78
Butler, Pa................	1903	18 000	1 270	56 (to Dec. 17)
Worthing, England........	1893	16 000	1 411	168 (Wells)
Maidstone, England.......	1897	33 830	1 928	150 (Springs)
Grand Forks, N. D........	1893–4	6 000	1 245	96
Tees River Valley, England..	1890–1	251 976	1 330	100
Lowell, Mass.............	1890–1	77 696	2 855	217
Lawrence, Mass...........	1890–1	44 654	1 792	137

The description in more detail of two epidemics of typhoid fever is of particular interest in showing how infected river water used for drinking conveys the disease. A series of typhoid epidemics occurred in towns in the valley of the Mohawk and Hudson rivers in 1890–91.

"In July, 1890, typhoid became epidemic in Schenectady and continued until April, 1891. Seventeen miles down the Mohawk is Cohoes, a city of about 22 000. Typhoid broke out here in October, 1890, and before April, 1891, there had been 1 000 cases. The disease was exceptionally mild; but notwithstanding this, the typhoid death-rate for the period of the epidemic was equal to an annual death-rate of 450 per hundred thousand of inhabitants, or about 12 to 15 times the normal.

West Troy, taking its supply also from the Mohawk above Cohoes, suffered from an epidemic from November, 1890, till February, 1891, except for a brief period, when the supply of the village of Green Island was used. Six miles below West Troy is Albany. Here again the disease became epidemic in December, lasting through the spring. Waterford, Lansingburgh and Troy took their supply from other sources than the Mohawk, or the Hudson below the junction with the former stream. So far as this outbreak was concerned, they escaped entirely. The progressive development of the disease in all of those towns that used water from the Mohawk, and its absence in other towns situated on the Hudson that were supplied from other sources, show conclusively the influence which the sewage pollution of Schenectady and other upper towns had on the distribution of the disease."

"A similar development was also noticed in the case of the towns of Lowell and Lawrence on the Merrimac River in Massachusetts. In 1890–91 an especially severe outbreak of typhoid occurred in Lowell, which was traced to the water supply. The source of supply was the river water, and it was shown that the probable origin of the polluted condition was attributable to several cases of the disease at North Chelmsford, a small village situated three miles above on a tributary of the Merrimac. These cases occurred in August, September and October."

"The sewage of Lowell empties into the Merrimac, and after eight hours' flow the river water is utilized by the city of Lawrence, nine miles below. The water polluted by the sewage of Lowell might thus reach Lawrence the same day. It would take several days (seven to ten) to pass through the supply reservoir before it found its way into the service pipes. A period of ten to twenty days is required to develop the disease after infection has occurred. From an inspection of the following table the direct relation between the outbreak in Lawrence and the polluted river water derived from Lowell is evident." (Turneaure and Russell, "Public Water Supplies.")

Deaths from Typhoid in		Lowell.	Lawrence.
September,	1890	8	3
October,	,,	10	3
November,	,,	28	7
December,	,,	26	19
January,	1891	19	19
February,	,,	14	11
March,	,,	10	6

The Lake cities and towns are also not immune from danger from sewage pollution affecting their drinking water when the latter is taken from the same body of water into which their sewage is discharged. As an example, Chicago may be cited before and after extending the water-works intake four miles into Lake Michigan.

Typhoid Death-Rates in Chicago, per Hundred Thousand of Population, before and after the Four-Mile Extension of the Water Intake.

Before Extension.

Year.......	'86	'87	'88	'89	'90	'91	'92	Average of 7
Death-rate .	68	50	47	48	83	160	104	years, 80

After Extension.

Year.......	'93	'94	'95	'96	'97	'98	'99	Average of 7
Death-rate .	42	31	32	46	27	38	25	years, 34

So characteristic are typhoid-fever death-rates that they have been suggested as an index of the quality and kind of water furnished any community. Fuertes has arranged the data for a total population of over thirty-three million, part being taken from European cities and part from American cities. I cannot give the chart, but the figures are approximately as follows. The figures mean the limits between which seventy-five per cent. of the death-rates per hundred thousand of population may be expected for the different kinds of water used.

Kind of Water Supplied.	Death-Rate per 100 000 in European Cities.	American Cities.
Mountain springs..........	2–11	2–10
Filtered water.............	4–20	3–20
Ground waters.............	5–34	5–37
Impounded waters..........	16–36	16–35
Normal rivers..............	18–39	18–38
Great Lakes...............	19–45	19–54
Upland streams............	29–59	28–58
Polluted waters............	41–100	39–100

In considering the death-rates of typhoid fever in recent years in this country, mortality statistics undoubtedly indicate a gradual decrease in this disease. That it is due to better hygienic conditions, and probably in a very large measure to the purification of water supplies, can be pretty clearly demonstrated.

The following figures indicate that we are eliminating this dread disease slowly but surely.

Total Deaths from Typhoid in Registration Area.

Year..............................	1907.	1908.	1909.
Estimated population in registration area..........................	41 758 037	45 028 767	48 776 893
Per cent. of total estimated population..	48.8	51.8	55.3
Total number of deaths..............	12 670	11 375	10 722
Rate per one hundred thousand.......	30.3	25.3	22.0

N. B. Rate for five-year period, 1901–5, 32.2. Distribution of rate for rural area in 1907, 26, and for urban area, 32.9. For 1908 the figures are 24.3 and 25.8, respectively. Figures for 1909 are not yet available.

While these figures are very encouraging, still even a death-rate of 22 per 100 000 is more than twice as high as the rate for England and Wales.

One of the greatest factors in the reduction of typhoid-fever rates has been the placing in operation of water purification plants in many of the large cities. For example, the state of Pennsylvania showed a reduction of 738 in its total number of deaths from typhoid between the years 1908 and 1909. Of this number, 313 fewer deaths, or 42.4 per cent. of the total reduction, took place in the two cities of Pittsburg and Philadelphia, whose water purification works were beginning and gradually extending their supply of filtered water.

To show how this diminution in typhoid is more specifically related to purified water supplies, the following figures have been compiled:

TYPHOID DEATH-RATE PER 100 000 OF POPULATION FOR FOLLOWING CITIES.

City.	1907.	1908.	1909.
Columbus, Ohio	38.3	110.5	20.0
Total number of deaths	57	168	33
New Orleans, La	55.5	33.1	28.4
Total number of deaths	177	107	95
Louisville, Ky	67.9	44.2	42.0
Total number of deaths	156	103	100
Pittsburg, Pa	130.8	46.6	24.0
Total number of deaths	502	255	130
Philadelphia, Pa	60.7	35.5	22.3
Total number of deaths	890	529	341

N. B. The filter plant was started in Columbus, August 19, 1908. Epidemic conditions were pronounced early in the year. The plant was in continuous operation in 1909. In New Orleans and Louisville the filter plants were started during 1909, but exact dates are not known. In Pittsburg and Philadelphia, the filter plants were placed in operation in 1908, but exact dates are not known to the writer.

From the typhoid statistics relating to the city of Cincinnati, a most convincing argument for a purified water supply can be presented.

Cincinnati.

Number of Cases and Deaths from Typhoid Fever.

	Unfiltered Water from Old Works.				Filtered Water from New Works.			
Year	1904	1905	1906	Total for 3 years.	1908	1909	1910	Total for 3 years.
Cases	1 646	746	1 940	4 332	235	218	183	636
Deaths	270	155	239	664	67	45	21	133

Number of Lives Saved in Three Years 531

If the above figures are stated as the number of cases and deaths from typhoid fever per hundred thousand of population, the effect of a purified water supply is even more striking.

Number of Cases and Deaths from Typhoid Fever per 100 000 of Population.

For Three Years before Introducing Filtered Water.	Average.	For Three Years after Introducing Filtered Water.	1908.	1909.	1910.
Cases	417	Cases	67	62	50
Deaths	64	Deaths	19	13	5.7

The percentage reductions in cases and deaths from this disease are shown in a convincing manner in the following table.

Percentage Reduction in Typhoid Fever since the Introduction of a Purified Water Supply.

Year.	Per Cent. Reduction in Cases.	Per Cent. Reduction in Deaths.
1908	84	70
1909	85	80
1910	88	91

There are other intestinal diseases, which are in all probability water borne. The figures in the following table are very significant in this connection.

Decrease in Certain Other Intestinal Diseases since the Introduction of Filtered Water.

	Unfiltered Water from Old Works.				Filtered Water from New Works.			
Year	1904	1905	1906	Total for 3 years.	1908	1909	1910	Total for 3 years.
From dysentery	27	21	22	70	9	11	5	25
Diarrhea and enteritis (over two years of age)	152	167	174	493	90	60	71	221
Total	179	188	196	563	99	71	76	246

Number of lives saved in three years 317

Grand total of lives saved in three years 848

View of the Two Large Settling Reservoirs of Cincinnati Water Works.

In distance can be seen Filtration Plant Buildings, Coagulation Basins and Clear Water Reservoir. In the background can be dimly seen the River Pumping Station and the Intake Pier.

The actual saving in dollars and cents to the people of Cincinnati, because of the introduction of a clarified and purified water supply, has been enormous. In fact, assuming each life saved as worth $5 000 to the community, then a sum of money amounting to $4 240 000 has been saved in three years' time. This statement takes into consideration only the financial side. The escape of hundreds from sickness and death, and the attendant anxiety and labor of those who would have cared for the sick, are certainly considerations of vital importance to any community. The increased attractiveness of the city as a business and a residential section, on account of the clear and pure water supply, is difficult to estimate; but no candid person will deny its reality. What is true of this city is also true of many others under similar conditions.

Methods of Purification of Public Water Supplies.

As was pointed out at the beginning of this paper, potable water should be attractive in appearance, that is, colorless or practically so, without odor and without taste. With the great variation in the natural qualities of waters, the problem of supplying a potable water becomes somewhat difficult. If to these qualifications is added practical freedom from bacteria and especially of disease germs, the real problem of the sanitary engineer becomes evident. I am going to survey, briefly, the methods and means by which a pure and wholesome water may be obtained.

The simple impounding of natural waters in large reservoirs doubtless produces a certain amount of improvement in the quality of the water. Vegetable coloring matter is bleached out by the sun; sedimentation occurs, relieving the water of some of its turbidity, and by dilution and natural biological processes a small amount of sewage pollution is probably satisfactorily eliminated. But in most cases this method is inefficient and especially so with much polluted or very turbid waters.

The filtration of water, therefore, becomes a necessity in the majority of cases. We divide the processes used in water filtration into two general types, depending chiefly upon the rate at which the water passes through the sand bed. One is known as the slow system of sand filtration, and the other as the rapid system of sand filtration.

In the slow system the water is filtered through sand beds of considerable area. This type of filtration is very old, the

process having been scientifically developed in Europe, where most of the large purification plants are of this type. The usual form of construction consists of embankments surrounding a square or oblong area of from one-fourth to one acre in extent. A bed of sand from three to four feet in depth rests on a coarser layer of small gravel, graded down to fairly good-sized stones at the bottom. An underdrain system of channels connected to a central collecting drain withdraws the water after its passage through the sand.

The gradual clogging of the sand bed necessitates scraping the surface layer at intervals from fifteen to fifty days, depending upon the character of the water filtered. From forty to eighty millions of gallons of water per acre are ordinarily filtered between scrapings, but this, of course, may vary widely.

Filters of this class can handle water having some turbidity, but the effluent is not at all times clear. The bacterial removal is usually high, being from 98 per cent. to 99.5 per cent. of the number found in the unpurified water. The rate of filtration is from two to three million gallons per acre daily. At least this is the more common practice, although higher rates are used. For turbid waters, this method of filtration is sometimes preceded by a period of sedimentation which removes a part of the suspended material. Vegetable coloring matter is not materially affected by this process. Waters containing a good deal of iron are sometimes successfully treated, if the iron is in the form of a carbonate. Aëration preceding filtration is in the latter case usually necessary.

The impossibility of clarifying turbid waters by simply filtering them through sand without preliminary treatment has caused to be developed another system of sand filtration in which chemicals are used to coagulate the suspended matter, and which permits the passage of the water through the sand bed at a rate from sixty to eighty times as fast as the slow system of sand filtration.

The coagulation of the suspended material is the most important part of this process, since on it depends the subsequent successful filtration of the water through the sand bed. Sulphate of alumina is used for this purpose, and also sulphate of iron in connection with caustic lime. The coagulating compound. where sulphate of alumina is used, is the gelatinous aluminum hydroxide formed by the reaction between the carbonates of lime and magnesium, naturally present in the water, and the applied sulphate of alumina. Where sulphate of iron is used, the ferrous com-

General View of West Side of Cincinnati Filtration Plant.

General View of Coagulation Basins of Cincinnati Filtration Plant.

Interior View of Filter House in Cincinnati Filtration Plant.

pounds first formed are converted into ferric hydroxide by the oxygen dissolved in the water. This latter compound is of a gelatinous insoluble character like aluminum hydroxide.

Coagulation of suspended matter causes the aggregation of the finely divided particles into larger masses, which settle out to a greater or less extent in preliminary settling basins. The partially clarified water then passes to the filters, where the remainder of the suspended matter is removed by rapid filtration through a sand bed.

Since the rate of filtration is from sixty to eighty times as fast as that possible in a slow system, the areas required for filtering are proportionally smaller. This greatly economizes space, as well as the cost of construction of the filter tanks. The cost of operation, however, is likely to be somewhat greater in the rapid system than in the slow system, since the cost of chemicals in the former may amount to quite a sum, depending upon the character of the water treated. In many plants, where the slow system is used, the cost of cleaning the sand has to quite an extent offset the cost of chemicals in the rapid system.

On account of the high rate of filtration and the turbid condition of those waters treated by the rapid process, it becomes necessary to have quick methods for cleaning the sand bed. This is accomplished by forcing filtered water up through the sand bed in a reverse direction from which it flows during filtration. The accumulated sediment on the surface flows off into gutters and from there to the sewer. Tanks round or oblong are commonly used for this class of filters. They have a strainer system at the bottom of the tank, consisting of brass nozzles perforated with small holes or slots, or perforated brass plates. A manifold system enables the filtered water to be collected into a common effluent pipe. Above the strainer system is usually a layer of small gravel, and resting on the latter is a layer of sand from 30 in. to 36 in. thick.

The tank capacity of each filter at the usual rates of filtration varies from 0.5 to 5 million gallons each per day.

Disinfection of water which is contaminated is a new departure in the field of water purification, which is of considerable significance. It is practiced both with and without filtration, but its chief value is as an emergency measure in cases of probable epidemics which may arise from sudden infection of a water supply. As a constant method for safeguarding filter supplies, whose sources are of necessity polluted, it undoubtedly is of great value, and is coming more and more into general use.

Even without filtration the method is found applicable for waters normally free from sediment and only subject to slight pollution.

Hypochlorites of lime and soda are the practical agents now employed in disinfection. Ozone has undoubted efficiency and many advantages, but commercially its cost and difficulty of application prohibit its use.

Cost of Filtration Plants.

Local conditions, of course, affect the cost of construction of purification works, and only in a very general way can such costs be stated. The figures given, therefore, are merely approximate, excepting where stated for specific plants.

In the slow sand filter plants the cost of excavation, embankment, cost of sand, etc., materially affect the ultimate cost. Large beds will cost less per unit area than smaller ones, other things being equal. Covered filters cost more than uncovered ones.

"At Berlin, covered filters of about 0.6 acre each have cost about $70 000 per acre. At Zurich, filters of one-sixth acre each cost, for the masonry and filter materials, only about $48 000 per acre for open, and $72 000 for closed beds." * As an average estimate in European practice, carefully designed open filters cost about $45 000 per acre, and covered ones about $68 000 per acre. In the United States the costs are about the same, possibly being a little bit higher, if anything. At Ashland, Wis., three covered filters were estimated to have cost about $70 000 per acre. At Poughkeepsie, N. Y., an open filter cost $42 000 per acre; at Berwyn, Pa., three open filters cost about $36 000 per acre; at Albany, N. Y., covered filters cost about $48 000 per acre, which appears somewhat low; and at Washington, D. C., covered filters cost about $75 000 per acre. To the cost of filters for plants of this type will usually have to be added the cost of a clear water reservoir, and sometimes sedimentation basins, amounting to $3 000 to $10 000 per million gallons' capacity according to circumstances.

The cost of operation of slow sand filter plants lies chiefly in the labor required for scraping the filters, and the cleaning and renewal of the sand. The cost of scraping will ordinarily range from $0.60 to $1.20 per million gallons of water filtered, although the removal of ice in open filters may greatly increase this price. The amount of sand removed ranges from one to two cubic

* Turneaure and Russell, "Public Water Supplies."

yards per million gallons filtered. The total cost of operating, therefore, amounts to $2 to $3 per million gallons. However, in some modern and recent plants these figures have been considerably exceeded.

In many respects it is more difficult to place an exact figure on the cost of construction of rapid sand filter plants than those of the preceding type. In a general way the cost will range from $8 000 to $12 000 per million gallons' capacity for filters, coagulating basins, clear-water well and auxiliary pumping apparatus.

The cost of operation is largely dependent upon the amount of coagulant used. In the more modern plants, which are carefully operated, the cost of operation will range from $4 to $6 per million gallons.

A few actual figures of the cost of construction of one or two of the larger rapid sand filter plants may be of interest:

TOLEDO FILTRATION PLANT.

Item.	Total Cost.	Cost per Million Gallons Daily Capacity.	
Intake, intake pipe and gate house	$52 372	$1 200	
Low service pumping station	125 542	3 900	
Water purification works:			
Head house	133 502	2 400	
Coagulation basins	101 200	2 500	
Filters and appurtenances	112 000	5 600	
Filtered water basin	65 000	4 000	$21 045
Filtered water conduit	200 726	3 345	
Land engineering, etc.	98 000	2 000	
Outside piping, conduits, walks, drives, lighting, tracks, etc.	71 415	1 200	
	$959 757	$26 145	

N. B. Costs per million gallons were estimated on a daily capacity of 60 million gallons. The plant as constructed now has a capacity of 40 million gallons. (*Engineering Record*, November 26, 1910.)

COST OF COLUMBUS PURIFICATION PLANT.

Item.	Total Cost.	Cost per Million Gallons Daily Capacity.
Settling basins	$168 770	$5 630
Head house	39 660	1 320
Air wash equipment	3 470	120
Lime saturator house	32 550	1 080
Mixing tanks	44 230	1 470
Storage house	12 880	430
Office and laboratory	15 280	510
Filter gallery	102 710	3 420
Filtered water reservoirs	98 300	3 280
Wash water tank, pipe and shelter	13 150	440
Miscellaneous	1 480	50
	$532 480	$17 750

N. B. The above plant has a daily capacity of 30 million gallons. It is a softening as well as a purification plant. (Trans. Am. Soc. C. E., Vol. LXVII, p. 206, June, 1910.)

CINCINNATI FILTRATION PLANT.

Item.	Total Cost.	Cost per Million Gallons Daily Capacity.
Preparation of grounds	$33 359.67	$297.85
Pipe lines between settling reservoirs and head house	55 354.77	494.24
Head and chemical houses	141 989.85	1 267.77
Coagulation basins, gate houses and pipe lines	304 913.05	2 722.44
Filters, filter house, piping, sand and gravel for filters	592 112.30	5 286.71
Piping, valves and gate house between filters and clear water reservoir	29 701.91	265.20
Clear water reservoir	121 362.39	1 083.59
	$1 278 793.94	$11 417.80

N. B. The capacity of this plant is 112 million gallons per day.

The settling reservoirs, which have a capacity of 330 million gallons of available water, are in part a portion of the water purification plant, although they also serve the purpose of storage basins, and were designed for such a use quite as much as they were for sedimentation purposes. Their cost was as follows:

Pumping mains between river station and reservoirs........	$191 193.71
Settling reservoirs..................................	1 521 156.17
Total....................................	$1 712 349.88

The cost per million gallons capacity is, therefore, $5 189.

[NOTE. — Discussion of this paper is invited, to be received by Fred. Brooks, Secretary, 31 Milk Street, Boston, by March 15, 1912, for publication in a subsequent number of the JOURNAL.]

POWER SYSTEM OF THE PACIFIC MILLS, METHODS AND RULES FOR, AND COST OF OPERATION.

By Fred A. Wallace, Member American Society of Mechanical Engineers.

[Read before the Boston Society of Civil Engineers, October 18, 1911.]

Object of Paper.

The principal object of this paper is to describe the power system which has recently been installed at North Lawrence, which supplies electric current at 2 300 volts for power and lighting to the cotton, worsted and printing departments of the Pacific Mills, with reference particularly to its maintenance and operation.

General Description of the Mills and Power System.

The Pacific Mills represent several textile industries located in North Lawrence, South Lawrence, Mass., and Dover, N. H., and employ nearly nine thousand operatives. The manufactured products are principally worsted and all-wool dress goods, printed and dyed cotton, worsted and silk fabrics.

An addition is now being built at South Lawrence, containing 1 320 000 sq. ft. of floor space, and will be, when completed, the largest print works in the world.

The entire Pacific Mills contain 6 168 000 sq. ft., or about 142 acres, of floor space and operate 404 360 spindles, 10 468 looms and 48 printing machines. There are 181 engines and turbines of 30 000 h.p., 165 boilers of 36 000 h.p. and water wheels of 7 500 h.p. There are also 625 electric motors of 17 700 h.p., principally alternating current, all of which are General Electric, including those in process of installation. The different departments consume 10 000 000 lb. of wool, 20 000 000 lb. of cotton and 85 000 tons of coal per year. The finished product of the printing department alone is nearly 2 000 miles per week of printed cotton cloth.

When the mills commenced to install more modern and higher speed machinery in place of some of its older equipment, more power was needed, and it was also realized that the old power apparatus was getting to the end of its useful life. These con-

ditions necessitated material changes in the power system, and after making a study of the conditions, it was decided to build the Central Power Plant, which is one of the largest isolated steam turbine stations in the world devoted entirely to the textile industry, and to adopt the electric transmission. The design and supervision of the construction was assigned to Mr. Chas. T. Main. This power plant and electric system form the particular subject of this paper.

In these days of the development of large industries, it would appear that from a financial as well as an operating standpoint, a large central station is more desirable than several small stations, and as to reliability, there can be no doubt that the electric transmission is as certain as any mechanical drive, and with many additional advantages.

Mechanical transmission of power is limited to comparatively small units, as, for example, a 5 000 h.p. engine which is now considered small in engineering problems can send its energy over small wires, while if belt driven, it would require a three-ply belt of leather, running at a speed of a mile a minute, nearly thirty feet wide.

In the old arrangement, there were at the Upper Mill, two 28-in. by 48-in. 106 rev. Buckeye engines of 750 h.p. each, connected to four water wheels; also a double walking beam Corliss engine was geared to four other vertical water wheels. The jackshaft of both sets of water wheels was connected by belt transmission through the several floors of the seven-story mill to different departments and by long lines of shafting and gearing to the print works.

The displacing of these belts and shafts by electrical transmission made room for much extra machinery, besides improving general conditions of cleanliness and fire risks. A great many sets of large bevel and spur gears were also removed by this change, which increased the general efficiency as well as eliminating a great deal of noise and mechanical troubles.

A Rice and Sargent cross-compound engine of 800 h.p. was removed from the Lower Mill. This load, as well as a large overload from the remainder of the power system, was transferred to the new central station.

The double walking beam engine which was removed by these changes was, for sentimental reasons, torn down with regret. As this was an engine designed over sixty years ago, a description might be interesting. It was of double walking beam type, having two vertical cylinders 38 in. by 84 in., both operat-

ing condensing. The fly-wheel was a gear 20 ft. diameter and 18 in. face, driving a pinion on the water wheel jackshaft.

The engine was in general appearance like the famous "Centennial Corliss," but not so elaborately finished. It was built by Nightingale, Bancroft & Co., of Providence, R. I., in 1847, and was one of the first engines in which George H. Corliss was interested.

It was made before the Corliss rotary cut-off valve was introduced, which was the greatest device ever applied to a steam engine and did more toward developing steam power economically than all other improvements since the time of James Watt.

The condenser pumps were of the regular plunger type with two large clapper valves on the piston and one large rubber valve for the discharge. They were driven directly from the walking beams and were supplied by water under a head of 6 ft. The engine was built to operate with 30 lb. steam pressure at thirty revolutions per minute, and the speed was controlled by a throttling governor.

In 1897 this engine was overhauled and the valves adjusted to run on low pressure steam which was taken from an exhaust system into which nearly 100 engines and pumps of various sizes exhausted. Enough of this exhaust steam was used by the engine to produce about 350 h.p., and the remainder was used for manufacturing purposes.

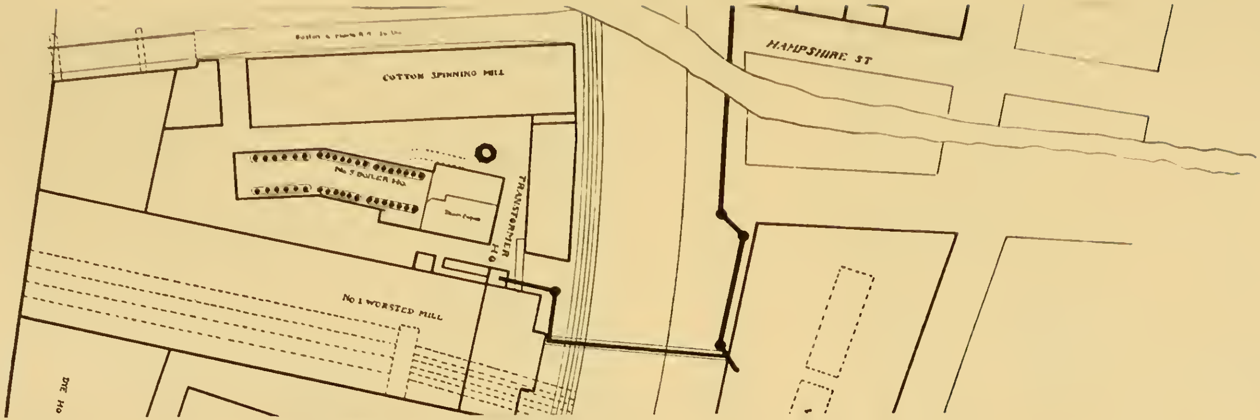
This engine is also interesting in that it was one of the first large power units to run on exhaust steam.

No tests were made to determine the economy, but it must have been good under the condition with which it was run. In the changing of this engine to low pressure and adjusting to increase its efficiency with a higher vacuum, the fact was realized that, according to thermodynamics, there is as much energy given up by a pound of steam expanding from 0 lb. gage pressure to 27 in. vacuum as when expanded from 150 lb. to 0 lb. gage.

This shows the great energy stored in steam at low pressures but which cannot be utilized with a cylinder and piston on account of prohibiting proportions.

This is the field which is now being taken by the low-pressure turbine and which promises to make great improvements in economical power generation.

It may be of interest to note that one pound of steam at atmospheric pressure occupies 27 cu. ft., while at 28 in. vacuum it is 351 cu. ft., and at 29 in. vacuum it is 705 cu. ft.


HAMPSHIRE ST
TRANSFORMER HO
COTTON SPINNING MILL
No 3 BOILER HO.
No 1 WORSTED MILL
DYE HO

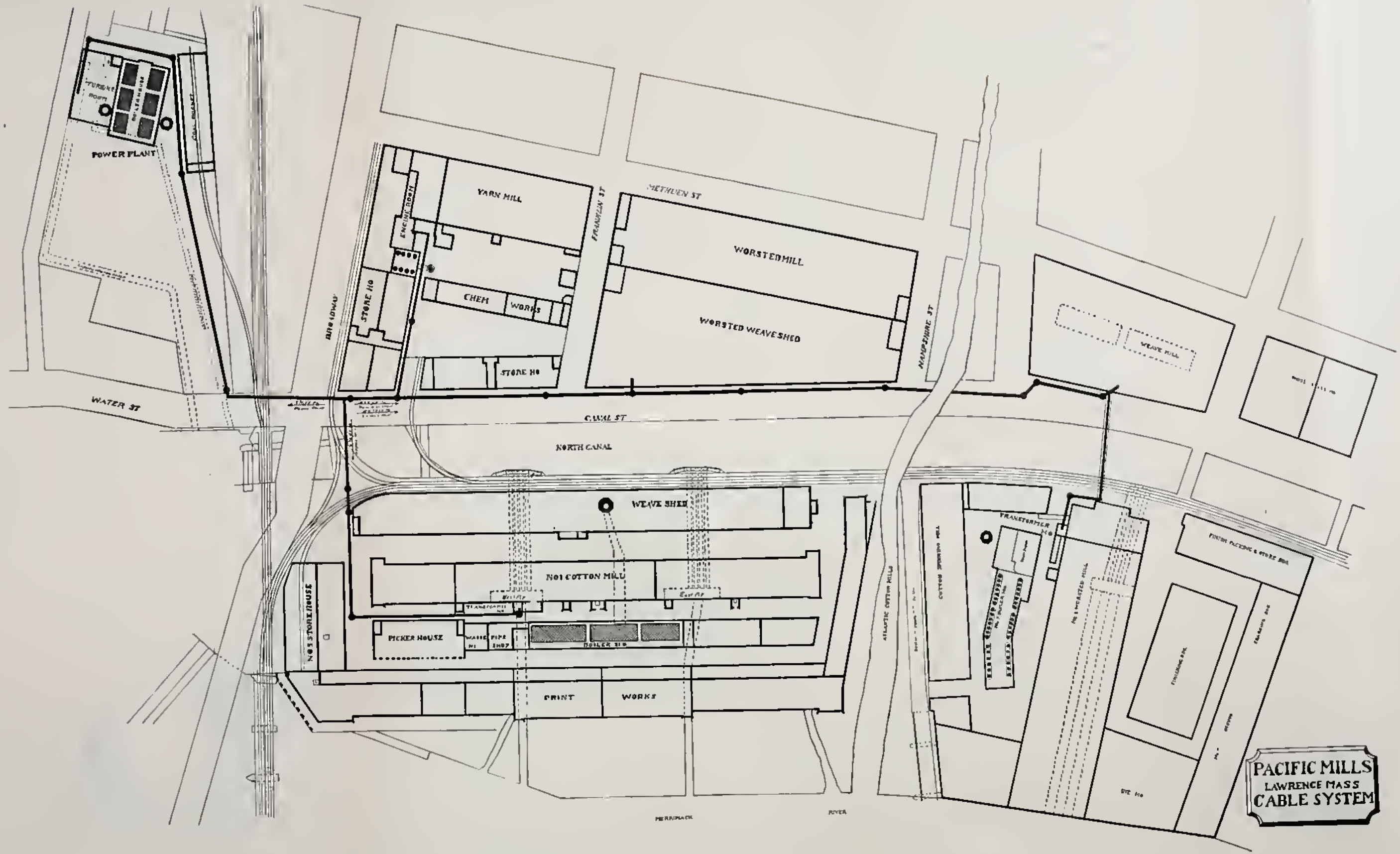

PACIFIC MILLS
LAWRENCE MASS
CABLE SYSTEM
POWER PLANT
YARN MILL
WORSTED MILL
WORSTED WEAVE SHED
METHUEN ST
FRANKLIN ST
HAMPSHIRE ST
CHEM WORKS
STORE HO
ENGINE ROOM
BROADWAY
WATER ST
CANAL ST
NORTH CANAL
WEAVE SHED
NO 1 COTTON MILL
PICKER HOUSE
BOILER HO
PRINT WORKS
NO 3 STOREHOUSE
WEAVE MILL
TRANSFORMER HO
ATLANTIC COTTON MILLS
MERRIMACK RIVER

FIG. 1.

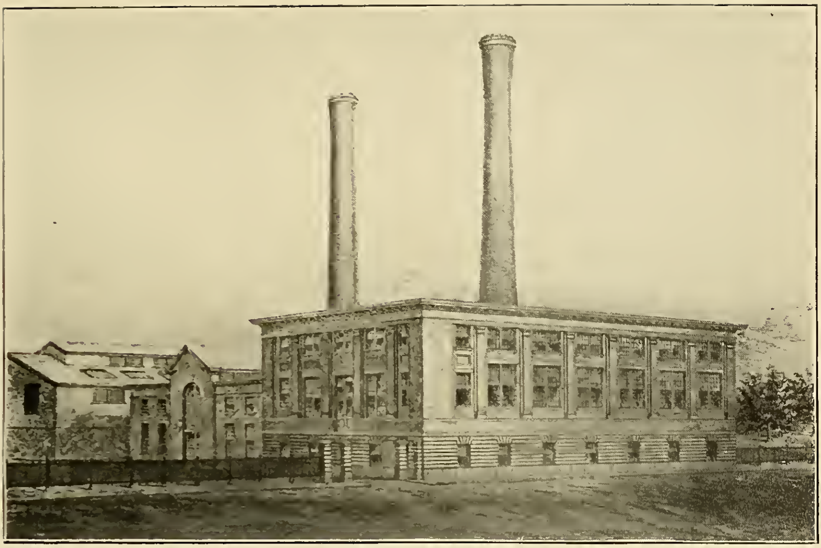


Fig. 2. View of Front of Power Station.

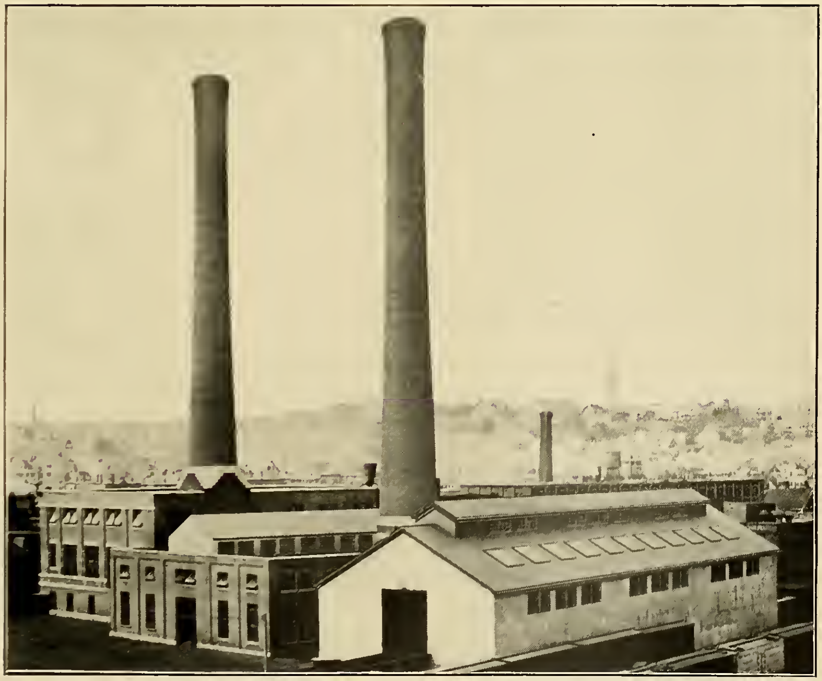


Fig. 3. View of Back of Power Plant.

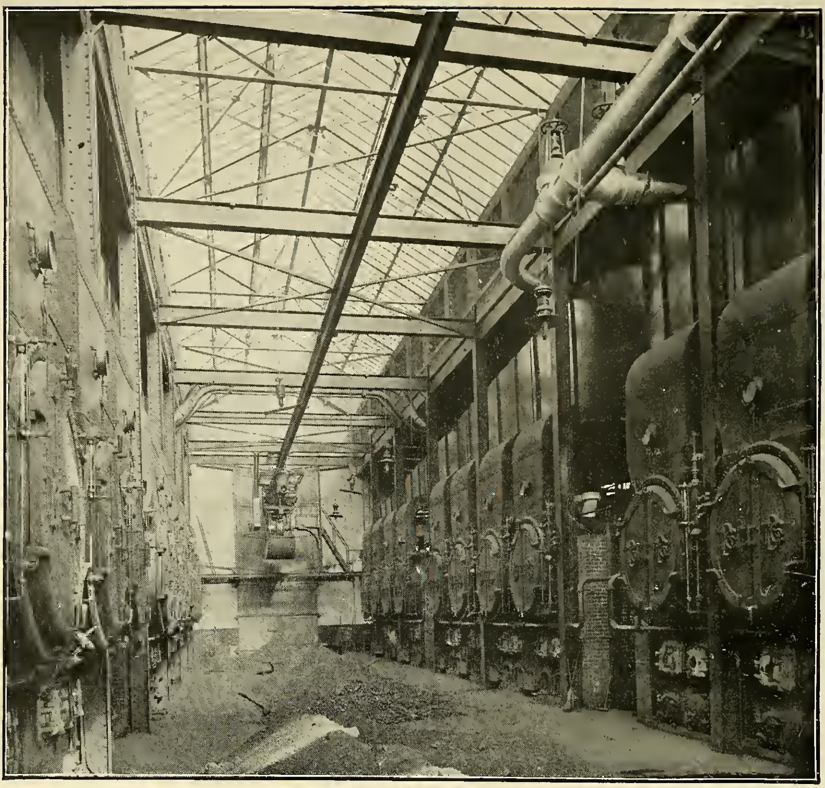


Fig. 4. Firing Floor of Boiler House.

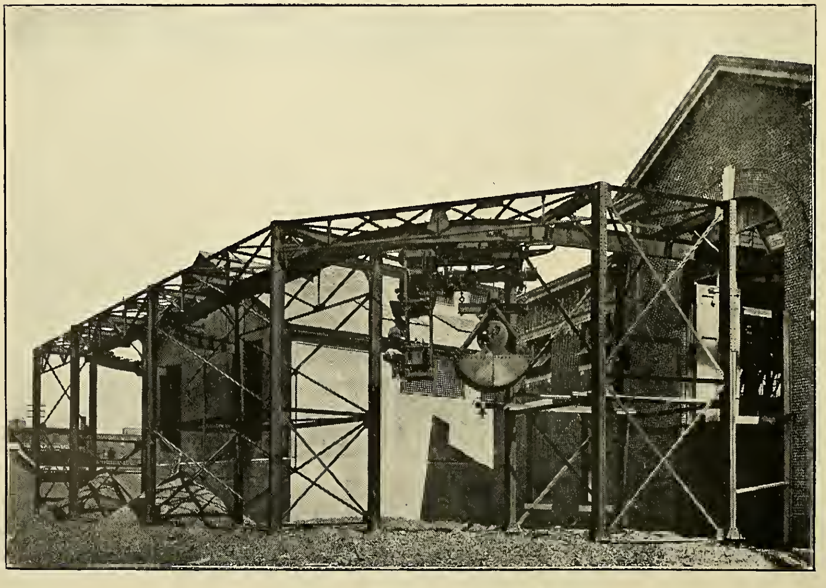


Fig. 7. Coal Handling Apparatus.

A large turbine was recently tested in England, which gave less than 8 lb. of steam per equivalent indicated horse-power per hour, and although obtained with a high steam pressure, superheat and vacuum, it shows that the steam turbine is making the largest gains in economy since the great changes brought about by the Corliss valve and use of steam expansively.

New Power Station.

About the time that the Power House was being built, additions to the processes of manufacture were installed, so that much more power is required now than with the old arrangement.

The new station is located on a three and one-half acre lot adjacent to the main line tracks of the Boston & Maine Railroad, about one-quarter mile from the Upper Mill, and sends current at 2 300 volts to four centers of distribution, the farthest of which is over two thirds of a mile away.

The plant consists of a building for the boiler and turbine rooms, and a separate coal pocket. There are two red brick chimneys which furnish all the draft required. The walls of the power house are of brick, the interior framing of steel, and the floors and roof slabs of concrete. The coal pocket has reinforced concrete walls and wooden roof. Every part of both structures is carried on simplex concrete piles.

The general arrangement of the plant is shown on folding insert.

Boiler Room.

The boiler house is 140 ft. by 87 ft., and is arranged with two rows of boilers and a 20-ft. space between them for coal storage and a firing floor. The floor is on a level with the yard, and with the turbine room basement.

A large skylight with louvres in the sides extends the entire length over the firing floor, making a light and well-ventilated room. The firing floor is of vitrified brick on concrete base. The toilet room for the employees contains modern shower baths with hot and cold water and individual lockers.

In the boiler room are twenty-four 72 in. by 21 ft. 6 in. horizontal multitubular boilers arranged in six batteries of four boilers each, twelve boilers being on each side of the firing floor.

The boiler tubes are $3\frac{1}{2}$ in. by 20 ft. long, and the total heating surface of each boiler is about 1 900 sq. ft.

The boilers can carry 160 lb. pressure according to Massa-

chusetts rating and have shells $\frac{19}{32}$ in. thick with quadruple riveted joints. They are set 30 in. from the grate, which has 36 sq. ft. area.

The boilers are suspended by brackets and rods from an overhead structure which is carried on cast-iron columns so that no load of the boilers can come on the brick walls or setting.

The steam leaves the boiler by a 4-in. pipe and passes through Foster superheaters set in the rear of the combustion chamber before entering the main line for distribution. All are connected to a 10-in. main steam header, from which steam passes to the different turbines and auxiliaries.

The steam is carried with as high a velocity as possible without an excessive drop in pressure in order to get the highest efficiency from the superheat, and averages 7 900 ft. per minute. Feed water is furnished by duplex steam pumps from the condenser discharge at about 75 degrees fahr. through an exhaust steam heater which raises the temperature to about 200 degrees fahr. This heater condenses the exhaust steam from the feed pumps, condenser pumps and engines, and an engine on exciter set, as well as the 75 kw. alternator engine.

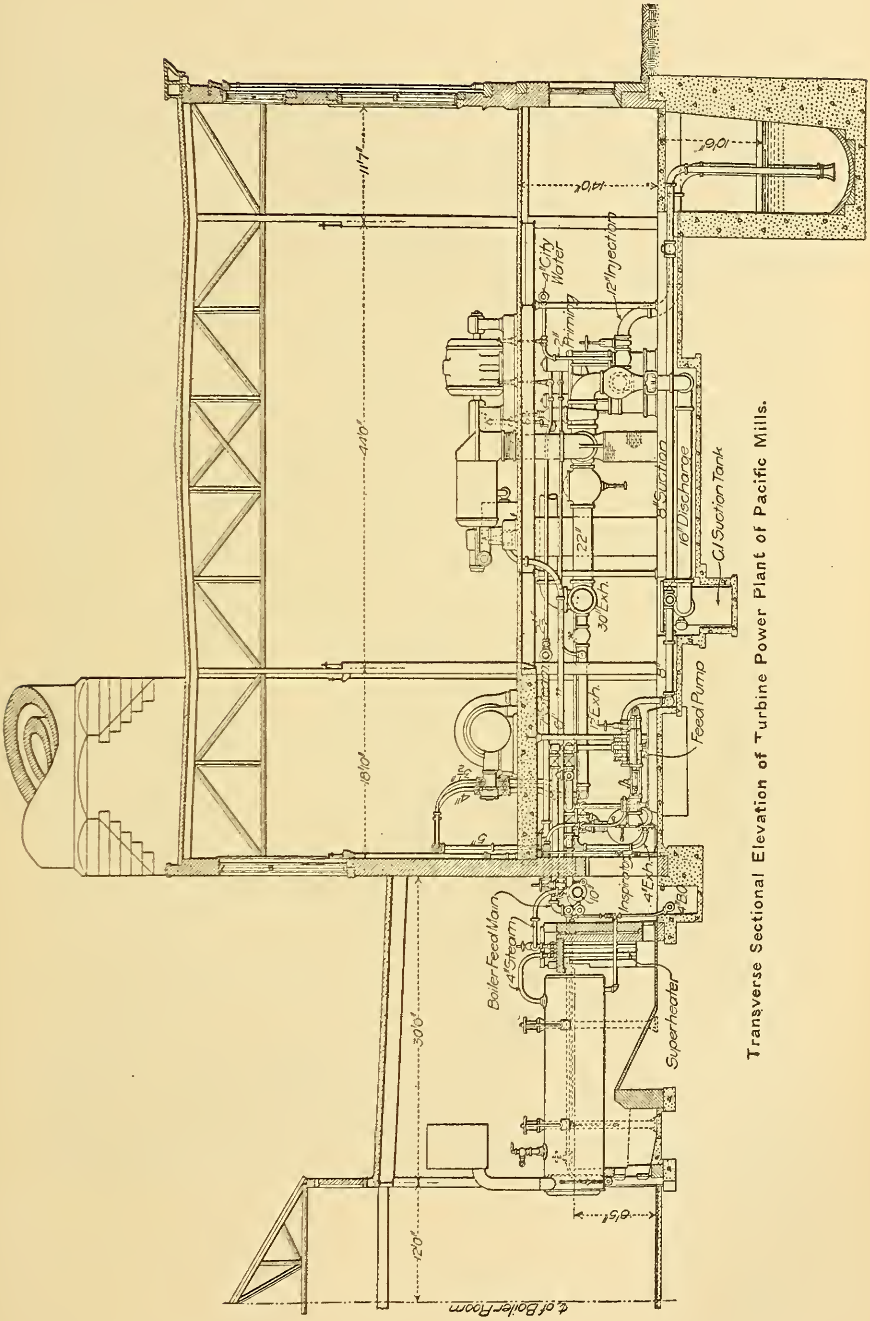
All piping is the 250 lb. standard with Van Stone type of joint and cast-steel fittings. All valves are steel body and bronze fitted with outside screw. Two stop valves, two blow-off valves and two safety valves are fitted to each boiler to insure safety and reliability.

The piping is arranged so as to avoid as far as possible any chances of serious trouble. The boiler feed piping is made so that any boiler may be fed with either hot or cold water in case of trouble with the other piping. For this purpose, a hot and a cold feed water main are installed and so arranged that any or all pumps may be used on either, or part of them on each. The steam for the auxiliaries is taken from an auxiliary steam header, which is connected to the main header near each end. With these arrangements, steam may be shut off from any section of the piping at almost any time.

The arrangement is also very convenient for testing, as the part of the plant under test may be separated from the rest of the plant.

All pipes and exposed parts of the boiler shell are covered with 85 per cent. magnesia, $2\frac{1}{2}$ in. thick, and particular attention is given to radiation from heated surfaces and leakage through boiler settings.

An ingenious arrangement for supporting the main 10-in.



Transverse Sectional Elevation of Turbine Power Plant of Pacific Mills.

steam header is that of a steelyard arm held at the ceiling and carrying weights to balance the load of the pipe and fittings. The piping was installed in place with all its fittings, valves and branches, but not connected to the boilers. The weights were moved to exactly balance the entire system, some levers requiring much more than others. When adjusted, the branches were all bolted to the boilers and the entire line was supported without any strain.

Each group of twelve boilers has a chimney 9 ft. inside diameter by 200 ft. high, built of common red brick on a concrete foundation carried on piles. Each chimney is constructed with a separate red brick core wall which takes the heat of the gases and allows for expansion and contraction.

There is a cast-iron cap at the top covering both core and shell. The part for core is separate from that for shell so that they may move independently. Collector points for the lightning arrestor are attached to this cap.

The twelve boilers are connected to the two chimneys by a sheet-iron flue 6 ft. by 10½ ft. and a double damper which is controlled by a regulator and maintains a boiler pressure to within one pound.

Turbine Room.

The turbine room is 126 ft. by 79 ft., with a basement of same size.

The basement is 14 ft. high, well lighted and ventilated, and contains all the boiler feed pumps, condenser apparatus, fire pumps, heaters, etc. Below the basement is a cistern, 105 ft. long, 10 ft. wide and 20 ft. deep, which is connected with a 48 in. penstock to the river about 1 000 ft. distant. This well supplies water for condensing and all other uses about the station.

The turbine room basement floor is of concrete laid directly on the earth. The trenches in this for pipes, etc., have cast-iron covers. The turbine floor proper is of reinforced concrete slabs on steel beams which are supported independent of the turbine foundations. The floor surface is of red tiles about 9 in. square. Much attention was given to this whole installation to make its appearance attractive.

The toilets for the engineers are similar to those in the boiler room and contain individual metal lockers and shower baths.

The station was first started in July, 1908, with three 750

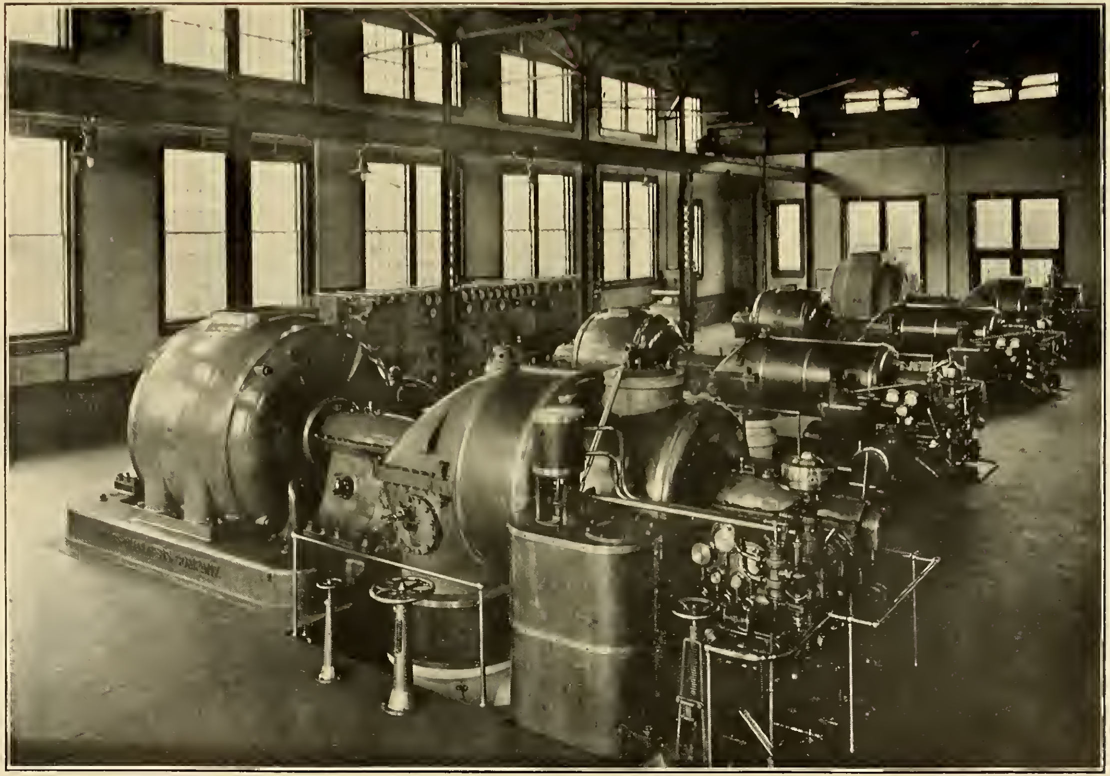


Fig. 6. Turbine Room.

kw. Allis-Chalmers steam turbine generating sets, and during 1909, a 3 250 kw. set of the same type was added.

Additions to the various processes have called for more power, and a second 3 250 kw. turbine, similar to the other, has been installed during the summer of 1911 to replace one of the 750 kw. machines. The machine displaced is to be taken to another part of the mill system where small units could be advantageously used.

As the station now stands, it contains two 3 250 kw. and two 750 kw. steam turbines with jet condensing outfits, two motor-driven exciter sets, one steam-driven exciter set, and one 75 kw. engine-driven alternator with exciter. A small motor-driven centrifugal pump furnishes all pressure water for the station.

The steam turbines are of Parsons reaction type, running 1 800 revolutions per minute with 150 lb. boiler pressure, 125 degrees fahr. superheat and 27 in. to 28 in. vacuum.

The condensing water after passing the jet condensers is returned to the river through a 48-in. penstock and has been raised in temperature 15 or 20 degrees fahr. The river water is nearly 32 degrees during several months in the winter and reaches a maximum of 85 degrees fahr. in the summer.

The turbo-generators are cooled by air supplied through a shaft extending above the roof next to the chimney. In this shaft are twelve bags, each 26 ft. long and 22 in. diameter, and made of cotton cloth of a suitable weave to admit plenty of air and to filter out all dust. These bags are cleaned every three months, and about six quarts of material collected, besides that which is fine enough to escape during the cleaning process. The deposit taken from the filter is composed of dust.

The small quantity is probably on account of the height of the entrance above the street. There is also a large percentage of carbon, which evidently comes from passing locomotives. This form of filter is very successful and is an absolute necessity for this dusty locality.

All alternating current in the plant is generated three phase, sixty cycle and twenty-three hundred volts. The switchboard for this station is along the wall at the west side of the room in a short span bay devoted almost entirely to electric wiring. This board controls all the generators and feeders. There is a panel of the switchboard for each exciter, one for each alternating current generator, a total load panel, and one panel for each main feeder circuit.

The power from it is distributed in large blocks to the

various groups of mills, where it is further subdivided into smaller feeders about the mills. The large power feeders to upper and lower mills are really tie lines between stations, as one of these already has generators installed and the other will have in the future.

The output of each generator is measured by an integrating watt-meter, so that the total energy generated is known. Then each feeder circuit has its integrating meters so that the power sent to each group of mills is known. The power used for driving the motor exciters, coal handling, pumping, lights, etc., about the station is also metered.

Each circuit is also equipped with indicating meters so that the instantaneous load and current may be obtained.

The current is sent from the station at 2 300 volts through lead sheathed cables in vitreous conduits underground to four main divisions.

1. Upper Mill power and lights, which is for cotton mill and old print works.
2. Yarn Mill lighting, which is for cotton spinning.
3. Lower Mill power and light, which is for worsted and woolen manufacture.
4. The new Worsted power and lighting.

Coal Pocket.

Coal is stored in a concrete pocket 210 ft. by 52 ft. holding 5 000 tons, with a storage depth of 20 ft., which is reached by a trestle from the Boston & Maine tracks. Cars are pushed up this trestle and dumped either into a main pocket or an auxiliary pocket. The floor of the main pocket is 10 ft. below the yard level and that of the auxiliary pocket at the yard level. The purpose of the auxiliary pocket is to be able to handle coal by automobiles to the boilers if any accident should happen to the regular coal-conveying system. A 6-in. pipe from the fire system is connected by a valve to the bottom of the coal storage so that, in case of fire to the coal, the whole area can be flooded as a last resort.

The coal-conveying system is a monorail grab bucket, traveling at about 400 ft. per minute and carrying 2 000 lb. The length of the average haul is about 350 ft. The working capacity of the bucket is about 12 tons per hour, allowing for weighing each load. This system is proving satisfactory and one man handles all the coal at a cost of less than two cents per ton, including labor, repairs, supplies and electric current.

2 300 Volt Transmission System.

The duct system is composed of multiple duct vitrified tile conduits laid in a concrete casing in the earth. The main part of this system near the power house has twenty-two ducts. They are laid up only two ducts wide so that each duct has at least one side exposed to the surrounding earth. This was done so as to avoid any chances of overheating cables on the interior of the system during the long period of steady load, lasting practically all day.

At the crossing under the street and railroad, a tunnel large enough to take both wires and pipes was constructed. Concrete shelves were built into the sides of the tunnel to carry the cables. These shelves are similar to those usually built in the sides of manholes for racking cables.

All the cables for transmission from the power house are varnished cambric insulated for the standard of 5 000 volts working pressure, and have the three conductors under the same lead sheath. The main cables are all either of 3/0 B. & S. or 4/0 B. & S. size. The large circuits are made up by connecting several of these in parallel at the ends, at disconnecting switches. With this arrangement, should a cable fail, it could be cut out and repaired later. This arrangement of disconnecting switches also makes a very easy method of disconnecting the cables for testing them.

Tests of the insulation of all cables are made each month, and the insulation resistances plotted for record. These tests are made with a Fisher testing set, fitted with a very sensitive galvanometer. These records are considered very valuable as we expect to be able to follow any deterioration of the cables and anticipate any trouble on the transmission cables.

Upper Mill Yard.

The current from the main power station is received near the center of the yard at a transformer station in power and lighting transformers and is there reduced to 550 volts for power and 115 volts for lighting before reaching the busbars of the distributing switchboard. At this station are three transformers, each 800 kilovolt-ampere, for power, and three transformers, each 100 kilovolt-ampere, for lighting, — all being water cooled. At another small substation in the yard there are three other lighting transformers, each 100 kilovolt-ampere.

Small auxiliary transformers are connected for light and

power when required for overtime work. These are located at the West pit transformer house, and each is 15 kilovolt-ampere.

The secondaries of all these transformers connect to the distributing switchboard for this yard located in the next room, at what is locally known as the west wheel pit. This switchboard also controls all of the output from the water power at the upper mill.

In the main mill cotton department there are good examples of group, four frame and individual motor drive installations.

The first installations of motors were all arranged to drive groups of machinery through short lines of shafting. This type of drive was admirably fitted for use in this cotton department where much of the shafting was already in place and required no changing.

Later, when some new twisting machines were installed and the motor for driving four frames by belts direct from the motor had been developed, some of this type were installed.

There are thirty-six pickers driven by 5 or $7\frac{1}{2}$ h.p. motors belted directly to the machine beaters. In making this change a large amount of shafting was removed from the picker room, benefiting efficiency, appearance and fire risk. The increase in the efficiency of this particular drive was surprisingly large. The motors for these pickers were mounted on the stand which formerly carried the countershaft for the machines. No trouble has ever been experienced with these drives.

Water Power at Upper Mill.

The water power is developed in two places, east and west wheel pits, each having two 39-in. and two 36-in. Hercules wheels, direct connected to generators. That for the east pit is of 800 kw. capacity, and that for the west pit, 600 kw. Current is delivered to the switchboard by these generators at 550 volts. Although there are four wheels connected to each of these generators, it is customary to run only two wheels on each, except at times of high back water and consequent low head.

The Pacific Mills at these two wheel pits have the privilege of using, during sixteen hours a day, water at the rate of twenty-five mill powers. A mill power is an arbitrary unit varying in different localities, and in this particular case is the right to draw water at the rate of 30 cu. ft. per second at 25 ft. head. This is equivalent to about 85 h.p. theoretically. Thirty feet gross head is to be had most of the year, although in the worst freshets, this has been reduced to 6 ft.

As the generator shafts are slightly lower than the highest known river level, extra precautions would have to be taken to protect them during severe freshets; as freshets which would wet the generators would probably occur once in fifty years, it was thought best to take the small risk of trouble from freshets and avoid any complicated construction in order to arrange the plant so as to be safe from these maximum freshets.

When the electric power was being installed, due to more rapid progress in the installation of textile machinery than was expected, the electric load greatly exceeded the generating capacity, as all the generators were not ready for service. The power factor at the time was low, being about 60 per cent. There were at that time many motors on the line which had only a small part of their load of machinery ready to run. The 600 kw. generator was erected, but the wheels were not ready. This generator was put on the line and run as a synchronous condenser, doing no work, simply floating in the circuit, carrying at times 50 per cent. current overload, and thus raising the power factor on the system so that the other generators could carry more power load. No trouble was experienced in running this generator in this manner and very satisfactory results were obtained. When the wheels were ready, the coupling bolts were put in and the unit put into regular service.

The east pit is in a different room and not visible from the west pit, where the switchboard is located. The east pit generator is controlled from the board by the regular attendant, who has only his instruments to go by and an arrangement for indicating the gate opening of the wheels. No difficulty has ever been experienced from this arrangement. An oiler at the east pit looks after the bearings, etc.

One very marked advantage of having these wheels connected to generators which run in parallel with the rest of the system is that they can be used for supplying power to any part of the system for night work. As the water can be used sixteen hours per day without extra cost, the water power can supply power to departments running a few hours overtime very cheaply.

Yarn Mill Yard.

Only the lighting load of this mill is carried by the new plant, the power still being generated by the Corliss engine, which is in good condition. Provisions have been left for changing over the power if it should be desirable in the future.

Lower Mill Yard.

The Lower Mill, or Worsted Department, is situated two-thirds of a mile from the power house which supplies both power and lighting current. Some engine power and water power with belt and gear transmission is still being used at this yard. These drives will be replaced to a great extent by electricity when the conditions are suitable to make the change. There is now an electric load of 1 600 kw.

This mill has a transformer house similar to the one at the Upper Yard, except that there is now no generator controlled from the switchboard. The transformer house contains three transformers for power, each 625 kilovolt-ampere, and three for lights, each 110 kilovolt-ampere. Other small transformers are located about the plant. The switchboard is in the basement adjoining the transformer house. It is designed so that generators can be controlled from it in future, if desired.

All the motors in this yard drive groups of machines through belts and shafting. As in the Upper Mill yard, all motors are wound for 550 volts, and open wiring is used from the switchboard to the motors.

The same metering scheme is carried out as at the Upper Mill.

New Worsted Mill.

The New Worsted Mill is driven entirely by electric motors of 2 300 volts. There are no small motors and conditions are ideal for the use of a high voltage equipment. This is the latest and most up-to-date installation and will consume about 3 500 h.p. The power wiring is all run in conduit, especially protected, making a very efficient form of distributing power. The smaller wires required and also absence of transformers about offset the extra cost of installing this 2 300 volt work as compared with that for 550 volt.

This mill has many group drives and four frame motor drives. In the four frame drive, one motor suspended from the ceiling drives four machines without requiring any shafting, the motor shaft being extended to carry two pulleys at each end. The four frames are set so that the tight pulley of each lines up with one of the pulleys on the motor.

There are twenty-eight of these drives where the motor runs 1 200 rev. per min. for the frame spinning, and twenty running 900 rev. per min. for the twisters. All are 25-h.p. motors. These motors are started by throwing them directly on the 2 300 volt

line, there being no compensator or other starting device, except the automatic oil switch. The motors are squirrel-cage type with silver soldered rotors. Started in this manner, they create no more disturbance on the line than starting an ordinary 100 h.p. internal resistance motor with its usual shafting load.

Thoroughout the power wiring in the mill, junction boxes have been used at switches and motors so that any piece of apparatus may be quickly removed from the circuit and replaced without having to break and remake permanent splices, all connections being made with lugs and nuts on small tablet boards.

Auxiliary Power for Night Use.

The 75 kw. alternator mentioned in the turbine room is used for supplying the current for the yard lights, which are on all night, and for such other small uses as may be required. In order to make this operation as simple as possible, and at the same time avoid exciting the large transformers, a separate or auxiliary transmission circuit was installed for this set. This is so arranged that the whole may be run in parallel with the rest of the plant, or the 75 kw. set and its feeder circuit and transformer equipment run entirely separate from the main circuits. The latter is the normal operating condition. Under this condition the set takes care of itself, except that the night man inspects the bearings, oil supply, etc.

Load Connected.

There is at present a connected load on the electric power system of about —

Lighting.	
Incandescent lamps, 16 c. p.	14 600
Arc lamps, 6 amp. A. C. enclosed.	187
Cooper-Hewitt Mercury vapor lamps.	360
Power.	
Induction motors, 224, totaling 9 548 h.p.	

Methods of Metering Power at the Station.

The four different main circuits all have total load integrating wattmeters as well as having wattmeters for the different departments on these circuits.

The power-house switchboard has seventeen panels of Vermont marble, five of which are for distributing outside of the

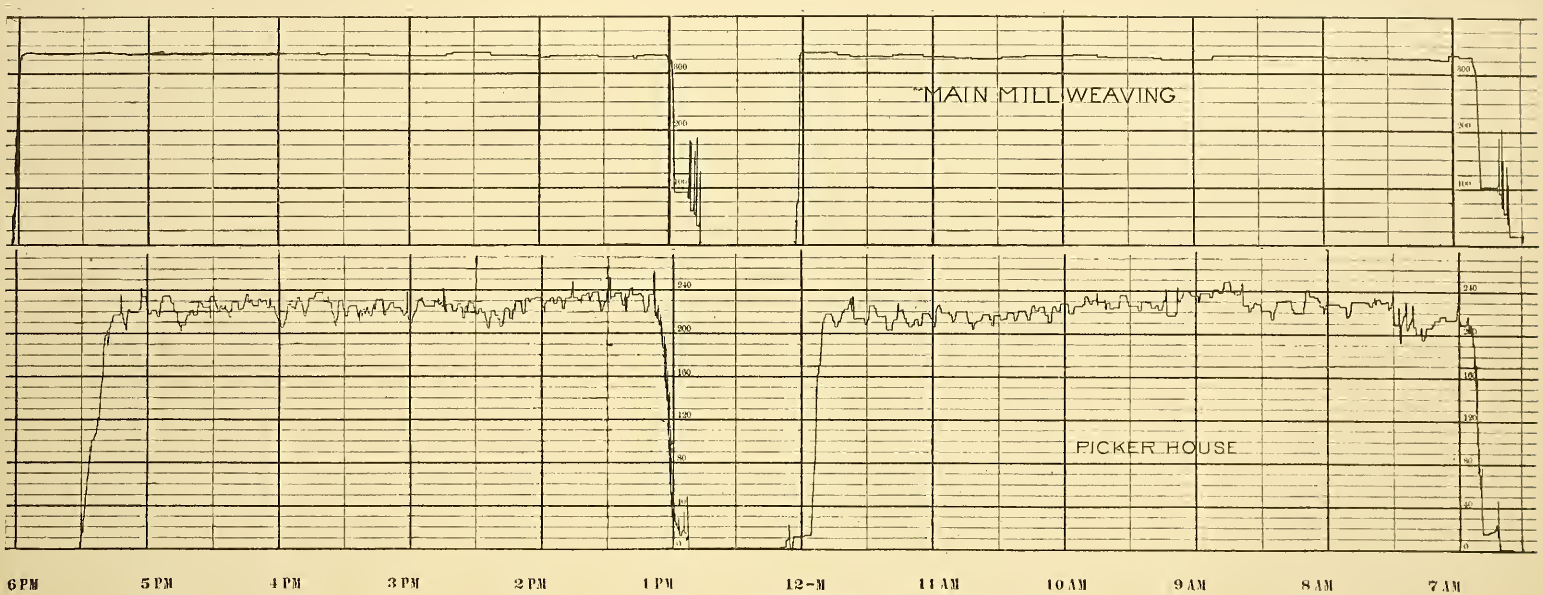


Fig. 8. Records of Curve-Drawing Wattmeters.

FIG. 9. RECORDS OF CURVE-DRAWING WATTMETERS.

station, one distributing for the station, one regulator panel, five generator panels and five exciter panels.

The output of the station is known daily from the integrating meters on each generator, and this in connection with the coal consumed gives the most desirable operating item, pounds of coal per kw.-hr.

All distributing switchboards have curve-drawing wattmeters on the different circuits leading to manufacturing departments, and by these the weekly records are kept of manufactured product and power required. Indicating wattmeters are also placed on every distributing circuit so that power required at any time can be noted. The records are very desirable and supersede the older methods of indicating the steam engines. These records from the curve-drawing meters are very interesting, as they show the character of the loads of the various departments and also indicate how well the machines are kept in service. These curves show some surprising information as to machines being stopped before the regular time.

For further information, an ammeter is placed at every motor and this allows any person to see at once any change of power due to temperature, humidity, tight belts, systems of oiling, machinery out of level, or any change of quality or kind of material manufactured. It also furnishes a very convenient way of making tests on the power to drive machinery under different conditions. The results obtained in this manner are probably not as accurate as could be made by more elaborate tests, but are close enough. Then, too, tests which can be made easily and quickly, even if only closely approximate, are more apt to be made than tests which require considerable preparation.

Reduced to a percentage basis, the following is the manner in which the power generated at the steam turbine station is used:

	Per Cent.
Upper Mill, Power	46.6
Upper Mill, Lights	2.6
Lower and New Worsted Mills, Power	47.0
Lower and New Worsted Mills, Lights	1.9
Yarn Mill, Lights	0.3
Station use	1.6

Method of Operating.

The success of operating is due to care, watchfulness and attention to small things, which makes it possible to foresee and prevent what might be serious accidents.

Any trouble in the power house, or generating systems, which would cause loss of production in any of the manufacturing processes is considered a serious offense by those who are responsible.

In the economical operation of the station much attention is given to the burning of fuel. The boilers are all hand fired, and an attempt is made to produce smokeless combustion. This can be accomplished with any fuel if a study is made of its composition and requirements for oxygen, for combustion is simply an oxidation. The boilers are set 30 in. above the grate and this height is well adapted to the usual grade of coal burned in this plant, but would be too high for a short-flame coal like anthracite, or would be too low for a smoky, long-flame coal.

For good results, the gases which are distilled from the coal should not come in contact with any cool surface until perfect combustion and mixing have taken place. Samples of these gases are frequently taken and an analysis showing 12 per cent. CO_2, 7 per cent. O, and 0 per cent. CO, is considered good practice.

In practical firing and every-day operating, approaching too near the theoretical may mean incomplete combustion and burning carbon to CO instead of CO_2 with a loss of 10 000 B.t.u. per lb. The secret of burning any fuel successfully in practice is to maintain a nearly uniform furnace temperature by firing in medium quantities, as the service demands, and then only over a portion of the grate. Just sufficient air should be admitted at all times to produce perfect combustion and the thorough burning of the gases before leaving the furnace.

Smoke is always an indication of imperfect combustion, and the loss of economy is not in the smoke itself, but in the imperfect oxidizing of the fuel. Much more attention will be given in the future than in the past to flue gas analysis in all coal burning operations.

The load factor of the station is practically $33\frac{1}{3}$ per cent., and although the load is quite constant for $5\frac{1}{6}$ hr. in the morning and 5 hr. in the afternoon, it starts and stops very abruptly, which makes it difficult to manage the furnace fires economically at these times.

All fires are banked at night, except those required to run overtime work on the regular lighting night circuits.

All the ashes are weighed before being taken from the boiler house and the percentage of ash entered on the weekly report. Every carload of coal is sampled and a chemical analysis made for fixed carbon, volatile matter, ash, moisture and B.t.u.,

and much attention is given to this record and its comparison with power-house results.

The steam pressure is controlled by damper regulators which also serve as a guide for firing, as the fireman practically works to this regulator and when the steam pressure drops even a fraction of a pound the damper starts to open and all the firemen together either level their fires or put on fuel in accordance with our alternate system of furnace control. This is on similar lines to modern steamship practice, except that, with their unusually steady load, they can set a gong to ring at definite intervals, at which every fireman does certain work on his furnaces.

The burned gases after passing through the boiler tubes escape directly to the main flue at a temperature of about 475 degrees fahr. There is no economizer.

The fires are cleaned at night by the night shift and the ashes wheeled in barrows to the ash pile outside the building. The ashes are sold for filling.

There are now four firemen and a boss fireman on duty day times, each fireman firing four 190 h.p. boilers. There are three firemen on night times. Two of these men clean the fires of fourteen boilers, while the third man cleans two boilers and is responsible for the station.

In any large power system it is very important that the generator speed be correct. We check the speed each day to keep the cycles correct, as the governor is changed each time the generators are phased together. In order to insure correct frequency for the system, the spindle speed for fifty-six hours and also for five-minute intervals is kept on daily and weekly records.

The help for the turbine room consists of a chief engineer, who also has other duties outside the station, two operating men, one oiler for auxiliary apparatus, one cleaner who is also a spare fireman.

The electric motors are started and stopped by electricians and helpers, each man attending to about 800 h.p. of motors. They are allowed fifteen minutes to get everything running and then take two ammeter readings before leaving this department to attend to other duties. During the remainder of the day these men trim arc lights, repair wiring, install any new work or make any changes in the lighting or power equipment which may be necessary; they also attend to fire alarms, danger signals and watch-clock system and all repairs and maintenance.

No one outside the electrical department is allowed to start

or stop a motor unless life or property is in danger. This arrangement is found to give better results than the previous one where the mill overseers and foremen started and stopped the motors. With the attention we give it, the electric drive has proven dependable and successful.

Cleaning and Inspection.

The motors and switches are cleaned by compressed air weekly or semi-weekly as location demands, weekly for all departments in the mill and print works, except carding, pickers, shearing and nappers, which are cleaned semi-weekly. Compressed air at 80 lb. pressure is piped over the entire area occupied by motors, and a valve and quick connecting coupling located at each motor. This same air supply is used also for repair tools, etc., when required. The air is used through a special nozzle which mixes room air and compressed air together and in so doing reduces the final jet pressure and also has a tendency to dry the air.

A sharp jet of air will possibly injure the windings and is especially dangerous when accompanied by moisture. This special nozzle gives much lower velocity than the initial pressure would give, and at the same time gives a much greater volume of air.

The generators are cleaned every three months, except the enclosed ones, which are supplied with filtered air, and these are cleaned about once a year.

A rigid system of inspection, including everything pertaining to electric generation and transmission, as well as elevators, fire risk and steam plants, is made weekly and is found to be of much importance in maintaining high efficiency. Inspectors have definite territory to cover and each one signs weekly reports which are kept on record.

As an example, the inspectors for the motors take the temperatures, inspect all wiring and connections, switches, oil in bearings, cleanliness and general conditions and also read the ammeters.

The headings and notes of the blanks for the Inspection Report are given below. In addition to this all of the usual power reports for a plant of the size are also kept up.

PACIFIC MILLS.

INSPECTION REPORT. Week ending 19

Weekly Inspection of Motors and Switches.

Bearings cool and properly oiled	except
Overload adjustment correct	,,
Work not excessive	,,
General condition of equipment	,,
General condition of cleanliness	,,
Air gap gages (monthly)	,,
Oil in switches (3 months)	,,
General wiring conditions for short circuits, fire, and personal injury	,,
Ammeters correct (6 months)	,,
Motor and switch contacts (3 months)	,,
Temperatures	,,

REMARKS: —

NOTE: — Record all Motor and Transmission troubles during past week. Weekly reading of Ammeter is on another report. Motor and Switch parts, Fuses, etc., on hand sufficient for emergencies. Oil in bearings and switches changed and properly filtered every six months. Remark when this is done. Particular care must be exercised in blowing motors with compressed air. The pressure must be low, no moisture present, and nozzle held so as not to injure the insulation.

Weekly Inspection of Generators, Switchboards and Transformers.

Bearings cool and properly oiled	except
Work not excessive	,,
General condition of equipment	,,
General condition of cleanliness	,,
Oil in switches (3 months)	,,
Oil in transformers	,,
Water circulation in transformers	,,
Cables tested (2 months)	,,
Manholes examined (monthly)	,,
Liability of transformers to freeze or damage	,,
Outside wiring	,,
Lamp equipment	,,
Overload adjustments on switchboard	,,
Insulation of armature and field	,,
Temperatures	,,
Switch contacts (3 months)	,,
Brushes and commutators	,,

REMARKS: —

NOTE: — The water-cooled transformers have two sources of cooling, and, in case of accident to one, use the other. Oil in generator bearings and switches changed and properly filtered every six months. Remark when this is done. Switch parts on hand, and fuses near switch boards and transformers for emergencies.

Week ending 19

Boilers stopped, number
How many times safety valves tested
Water changed in boilers, number
Boilers opened and cleaned, number
Tubes scraped
Tubes blown
Boilers inspected, number
Blow-off valves tight
Steam gages correct
Leaky joints, tubes, etc.
General cleanliness
Furnaces needing repairs
Superheaters
General piping equipment
Feed pumps
Heater drained and cleaned
Engine cylinders examined
Air pumps examined
Heating and Ventilating equipment
Fuse Plugs and Low Water Appliances
Combination chambers tested

REMARKS: —

Note all shutdowns, extraordinary repairs, and changes to boilers or equipment.

Fortnightly Inspection of Sprinklers and Fire Equipment, etc.

Valves found open	except
Valves found strapped	,,
Air valve pressure (weekly)	,,
Air valve equipment	,,
Hydrant equipment	,,
Standpipe and hose equipment	,,
Hose house equipment	,,
Fire pumps tested (weekly)	,,
Window sprinklers	,,
General cleanliness in rooms	,,
Heating pipes free from rubbish	,,
Oily waste	,,
Fire doors	,,
Fire pails	,,
Gas leaks	,,
Elevators (monthly)	,,
Indicator posts open	,,
Buildings, roofs, bridges, etc.	,,
Pipe covering	,,
Fire alarms tested (weekly)	,,
Danger signals	,,

REMARKS: —

NOTE: — The Standard air pressure on air valves is 30 lb.; and the valves open at about 13 lb. Record standpipes and sprinklers which are shut in the fall and opened in the spring. Hydrants must be tested before freezing weather.

Records.

A system of weekly reports is kept on file, which gives daily and weekly operating figures on all important items about the different power stations and includes current generated, weight of coal and ashes, temperatures, pressures, oil and waste, labor of operating and repairs, supplies, division of costs, etc. A complete set of curves is also kept of these items, which show at a glance the comparison of any week and year.

These figures are inspected each week by the chief engineer of the plants and the author.

Tests.

The acceptance tests of 3 250 kw. turbine at 100 per cent. load was 15.40 lb. of steam per kw.-hr., with 150 lb. boiler pressure, 125 degrees superheat, 28-in. vacuum with barometer at 30 in. and condensing water at 70 degrees. At other points the steam used was, 50 per cent. load, 17.83; 75 per cent. load, 15.50; 125 per cent. load, 15.46; and 140 per cent. load, 15.84.

Tests on the 750 kw. turbines under the same conditions gave for 75 per cent. load, 18.92 lb.; 100 per cent. load, 17.84 lb.; 125 per cent. load, 16.63 lb. steam per kw.-hr.

The auxiliaries, including condensers and feed pumps, use about 12 per cent. as much steam as the main unit. This test was made with the 3 250 kw. turbine delivering 3 810 kw., two condenser pumps, one feed pump and the Holly drip return system constituting the 12 per cent.

During nights and Sundays, the 75 kw. lighting set, the 50 kw. exciter set, which is used for charging electric automobile storage batteries, and a boiler feed pump are run, and this load, together with the loss due to banking and cleaning fires, brings the weekly coal consumption to 2.3 lb. of coal per kw.-hr. for the total current generated.

The station is operated at present at 3 600 kw. As this is only about 65 per cent. of its past rated capacity, the economy is not as high as it might be. Within the next few months this load will be increased to about 6 100 kw. The station now has a normal capacity of 8 000 kw.

Operating Costs.

The following figures are for cost of operating an average week on 3 600 kw. These are the conditions under which we have been operating for the last year.

Turbine room labor, 5 men, and superintendence...	$99.85
Boiler room labor, 8 men........................	99.15
Fuel, at $4.25 per long ton in pocket..............	880.00
Oil, waste and supplies and repairs................	37.05
Total operating expenses per week..........	$1 116.05

During the week, 204 780 kw.-hr. are generated, giving a cost per kw.-hr. of 0.545 of a cent.

Within the next few months the load will be increased, due to the putting into service of all of the new worsted mill, to about 6 100 kw., giving a weekly output of approximately 340 000 kw.-hr. per week.

At this time, the normal operating condition will be to run the two large turbines, leaving the two smaller ones as spares.

To operate the station under these conditions will cost —

Turbine room labor, 5 men, and superintendence...	$99.85
Boiler room labor, 9 men........................	108.95
Fuel, at $4.25 per long ton in pocket..............	1 483.25
Repairs and supplies............................	58.60
Total operating cost per week..............	$1 750.65

$$\text{Operating cost per kw.-hr.} = \frac{\$1\ 750.65}{340\ 000} = 0.515 \text{ of a cent.}$$

The station as it now stands with 8 000 kw. normal capacity of generators, cost, with land and everything up to and including the switchboard, a little less than $90 per kw.

Figuring the fixed charges on this at 11 per cent. we get —

$$11 \text{ per cent.} \times 720\ 000 = \$79\ 200 \text{ per year.}$$
$$\text{or } \$79\ 000 \div 52 = \$1\ 523.08 \text{ per week.}$$

With station generating 340 000 kw.-hr. per week, the fixed charges will be

$$\frac{1\ 523.08}{340\ 000} = 0.448 \text{ cents per kw.-hr.}$$

The total cost then per kw.-hr. at the switchboard, for the 6 100 kw. load on the plant, will be —

Operating expenses per kw.-hr..........	0.515 of a cent.
Fixed charges per kw.-hr..............	0.448 of a cent.
Total...........................	0.963 of a cent.

The same figures if this plant should be operated at its full capacity of 8 000 kw., as is quite customary in textile mills, would be —

Operating charges per kw.-hr.	0.501 of a cent.
Fixed charges per kw.-hr.	0.340 of a cent.
Total cost	0.841 of a cent.

Analyzing these costs for the operating conditions of 6 100 kw., it is found that in percentage of the total cost —

	Per Cent.
Labor is	6.4
Fuel is	45.5
Repairs and supplies	1.8
Fixed charges	46.3

These figures plainly show that the two items from which any great saving may be expected are —

First. Less fixed charges.

Second. Better fuel economy.

We can also calculate how much more expensive and efficient apparatus we could afford to install to help out the fuel charges, remembering, however, that the more complicated apparatus invariably requires more expense of repairs and depreciation. The principal object in view in the design and operating of this station has been simplicity and reliability, and these have been obtained. Many of the requirements which are supposed to make for refinements in efficiency have been omitted, particularly in the boiler room, where simplicity was especially desired. We prefer to operate a boiler plant as far as possible without many of the automatic devices on the market, as without these there are less parts to get out of order.

When the old mills were changed from engine to motor drive, a great amount of shafting and belting was removed and this in itself is one of the motor's best recommendations, not mentioning flexibility of service, ability to check power required at any time, and increased production, due to more uniform speed. We have no accurate way of knowing whether the total power of the mills is more or less with the electric driving than with the old system, but probably the losses in one system would about balance those in the other.

It is of interest to mention that, in these days of high economy, we are only realizing 10 per cent. of the energy in the coal which we burn at the power house, on the pulley of a machine in the mill.

An interesting feature in the electrification of these old mills is an excellent example of the evolution of the steam engine.

The old Corliss engine, which was previously referred to, and which was associated with George H. Corliss in his earliest engineering experiences, was purchased as a high-pressure, high-speed machine, requiring 30 lb. steam pressure and 30 revolutions per minute, developing 450 h.p. through gearing to a limited area, while the steam turbines of to-day are made to 30 000 h.p. in one unit using steam of over 200 lb. pressure and a superheat of over 150 degrees fahr. and can send their electrical energy over several hundred miles.

DISCUSSION.

MEMBER. — I would like to ask what the present power factor is.

MR. CHARLES ROBINSON. — The different parts of the system vary, but somewhere in the neighborhood of 80 or 85 per cent.

CAPT. CHAS. H. MANNING. — I am very much obliged to the author of this paper for preparing it. Not that I heard any of it, because I cannot hear well enough, but I had a copy of it and read it before I came. Knowing the locality pretty well, I could follow the pictures and imagine what was being said. I have no criticism to make on the paper. I think this is a very beautiful plant and very ably described. Any criticism I may make is in regard to our good friend, Mr. Main. He and I live more or less in glass houses, and he cannot afford to throw many stones, nor can I. I think, however, that he has fallen into the same error that a good many others have, in fact pretty much all of us do sooner or later, — that is, he started out on entirely too small a scale, considering the plant he had to deal with and the locality. In the first place his boiler house is too small for that corporation. They require at least 20 000 h.p. now. That boiler house and its equipment could not begin to supply them. Mr. Main, or the authorities above him, ought to have started out with a boiler house big enough to run the whole business that was in sight and 50 per cent. more. It has been his experience, I know, just as it has been mine, that we always start too small. He has followed in the footsteps of our distinguished friend, Mr. Leavitt, and my friend Mr. Diman, and gone back to the horizontal tubular boiler, — I suppose for good reasons. I have not yet had a chance to ask him what the reasons were, but I suppose they were good ones. I do not agree with him, and never have, on that point. I believe a vertical boiler

is better than a horizontal one. About one of the very first visits I made when I went into power engineering was to the Pacific Mills, about thirty years ago, — and they were then busy pulling out their old horizontal tubular boilers. They had been in use about thirty years and had done splendid work, but they wanted a boiler of higher pressure and they were pulling them out. These were probably put in at about the same time as those old Corliss double-beam engines. Why Mr. Main used a machine of 750 kw. I do not know. The first time I saw a description of the plant and it said there were four 750 kw. turbines going in, I thought the printers had left off one of the ciphers. I supposed, of course, he was putting in a machine big enough to pay for itself. Undoubtedly he had good reasons for what he did. He may tell us why. A four-machine plant to give 3 000 kw. costs a good bit more than one machine would. It costs more to run, to take care of, — and I think his hind-sight was better than his foresight, and he reformed and put in one fair-sized unit. But if he had started and laid out for four 3 500 kw. units to begin with he would have done better. I think he should have put in bigger machines; but I think he did certainly put in beautifully arranged machines and they have done good service. The arrangement of the steam piping I think is too small. I think his idea is all right, for high velocity of the steam, to get it along while it is hot, but I think when he gets over 100 ft. a second — that is, over 6 000 ft. a minute — that it is going too fast. You get a drop of pressure that can be avoided. In the description of the old Corliss engine there was one thing that struck me and which shows that neither the man who wrote the paper nor Mr. Main are marine engineers. In the description of the air pump it is spoken of as a plunger pump. I do not believe it was. I rather think it was a bucket pump, the same as was used on all the old beam engines thirty or forty years ago, — that is, valves on piston and valves at the bottom; and it acted as the bucket does, went down into the water and picked the water up just as you would in a bucket, and poured it over the side. The old marine engine had another valve yet, which stood right at the top of the barrel and lifted when the water came out and then closed and formed a partial vacuum. Whether this pump was arranged that way I do not know, but it certainly was not a plunger pump.

Mr. Chas. T. Main. — I think you can all see that I have not had a chance to talk this thing over with the Captain before coming here. I can answer some of his criticisms. With respect

to the type of boiler used there, the officials of the mill said that this type of boiler had given them very good service for many years and they knew that they were very economical, and they decided they wanted to use them. I was also sure it was quite an economical boiler and, therefore, agreed with them.

With respect to the size of the first units put in there, I would say that in the earlier days of steam turbines the owners of the mills were a little skeptical as to what was going to happen, and, therefore, were very cautious. In this particular case we recommended units of a larger size, but our recommendations were not adopted, and that accounts for the 750 kw. units. As soon as the small units proved to be so successful it was decided that when another unit was put in it ought to be very much larger than the first one.

The fourth unit installed was 3 250 kw. With respect to the steam piping, I think the operation of the station has proved that the velocity is not high enough to make any drop of any consequence in the pressure.

Mr. R. A. Fessenden. — This paper is so full that there is very little to ask, but there are one or two points in regard to which I would like to secure information. What is the efficiency of the electrical drive in cotton mills as compared with the old belt drive? In machine works, like the Baldwin Locomotive Company, the figure is 330 lb. of steam for the electric drive as compared with 1 000 lb. for steam engine and belting, but of course you would not expect to get so great saving in the case where there is a steady load all the time; still, one would imagine you would get some, and I would like to know how much.

The second point was whether the old tubular boiler has been thought of in connection with cotton mill driving, for the reason that it has very large thermal capacity. It has gone out of fashion of late years, but it has advantages when one has fluctuations in load, like shutting down at noon, and one can shut down the boilers some time before the end of the day and greatly reduce stand-by losses. This is especially the case when used in connection with steam turbines, because the lowering of pressure of the steam turbine does not make so much difference as long as you have good thermal storage. I would like to know what the disadvantages of this type of Scotch boiler would be.

There is one other point about the high speed of the steam in the pipes. That does not make much difference in the steam turbine because wherever you get high speed it simply means in effect so much more throttling and so much more superheat,

so that it does not give the loss one might imagine it would. In fact, it is a good thing as it tends to dry the steam. If the pipes are well insulated, within limits the more friction the better.

Mr. Main. — I think I can answer the first question. The friction load in a cotton mill is quite small. It is not apt to be over 25 per cent. or 20 per cent. in a well-designed mill, and the load is very constant, as you saw from the diagrams presented. The mechanical friction losses are no more than and probably a little less than the electrical losses in the textile mills. This is very different from a machine shop where the friction load may be from 50 to 60 per cent. It was mentioned in the paper that they had not been able to compare the losses when running under the old system and the new system, but that Mr. Wallace thought there was very little difference.

I do not know of the use of the Scotch boiler in this locality to any great extent, but it is used around Philadelphia quite largely.

Mr. Fessenden. — As I pointed out, it is true that it is rather old fashioned, but it went out of style largely because it could not make steam quickly; but in cases where one had a steam turbine which worked at quite high efficiency, with considerable reduction of pressure, there might be some use for it again and it might become new fashioned again.

Mr. Main. — About 1885 there were installed at the lower Pacific Mills a lot of Galloway boilers. They gave very good service and remained there several years, until more power was required. There was no more space in the yard to put more boilers of this type in, and then Manning boilers were put in.

Mr. F. M. Gunby. — I wanted to discuss a little the question that was brought up by a question which Mr. Loew asked me about a year ago, and that is why, in a textile mill, a central station of this type, entirely separated from the rest of the plant and making no use of the by-products, should be a good investment. In other words, the engineers have been using a system of exhaust steam to reduce the cost of power. Mr. Wallace says in his paper:

"In these days of the development of large industries, it would appear that from a financial as well as an operating standpoint, a large central station is more desirable than several small stations."

It is this phase of the question which I wish to discuss. Several years ago, when the power question at these mills first

came up for study, due to the wearing out of the old apparatus and the then proposed reorganization of the cotton department at the Upper Mill yard, several tentative plans were made for furnishing the required power by installing new apparatus in a power house to be located in this yard. These schemes all contemplated using the new plant in conjunction with certain parts of the old system and also getting the benefit of the saving possible by the use of exhaust steam for manufacturing and heating. As there was not space in this yard to build a plant large enough for both, it would have been necessary to build another plant at the Lower Mills, where the existing plant was much overloaded, and to build a new plant for each future group of mills which might be built. These plants would have been of only moderate size, and their design would necessarily be complicated by the small space available for time. They would, of course, have had the advantage of having the net cost of power reduced by using their by-products for manufacturing and heating. This reduction would have been a large amount for the Upper and Lower Mills where printing and dyeing were done. This saving would have been offset somewhat by the fact that the cost per horse-power of installing, and the fixed charges on them, would have been higher than on a large station. When the mill management decided to build the new central power station entirely separate from the rest of the plant, it assumed a position new to the textile industries of this type. The farsightedness of this course has been demonstrated by subsequent events, notably the already large growth of the station from its original size and the probability that it will grow larger, the cheapness of the power from the station, and the ease and relatively inexpensive manner in which the power plant has been increased so as to furnish power for an entire large new mill. Further additions may be made to the plant at will and at comparatively small cost per unit of capacity. A three-and-a-half-acre lot has been reserved for the power plant, and the present plant covers only about one third of this space. The advantages of this new central station might be stated as —

1. The ease and cheapness with which extensions of the power plant and system may be made to meet any demands made upon it by the manufacturing plant.

2. The concentration of the power apparatus in one plant, with the consequent saving in labor and in the aggregate amount of relay capacity required.

3. The great flexibility of the power station.

4. The use of large generating units with their greater economy and less first cost per kilowatt capacity.

5. The small first cost per kilowatt of station capacity for the larger station. As pointed out in the paper, the fixed charges on the cost of a kilowatt hour are 46.3 per cent. of the total cost, showing that there is a large chance for saving on these fixed charges. The cost per kilowatt of capacity of a station, and the cost per kilowatt hour of the power delivered by it, are greatly affected by its size. For a station of this type, having steam turbines, with coal costing $4.25 per ton, these costs, exclusive of charges for land, would be about as follows:

Size Plant.	Cost per Kw. Capacity.	Cost per Kw.-hr. for Power.
1 000 kw.	$125	1.25 cents.
2 000 kw.	110	1.08 cents.
3 000 kw.	100	1.00 cents.
4 000 kw.	95	0.96 cents.
5 000 kw.	90	0.94 cents.

Mr. Main. — I neglected to answer one of Captain Manning's criticisms. A lot is reserved for the future growth of this station. The two stacks are also built for doubling up the capacity of the station, and all that it is necessary to do is to extend the house and put in apparatus at any time when the power is needed.

Mr. Amos G. Hosmer. — I think there was a mistake made, nevertheless, in its not being made possible to use that warm water. There is abundant use for warm water, notwithstanding that the power cost is very low; and I think it could be bettered quite a little by its being made possible to use that immense amount of heat that goes out into the river; and also I think you lose quite a lot in the long transmission lines which could be saved by having the station in a more central place. Another point Mr. Gunby makes is that this was the first move in the way of a central station for a cotton mill. This is wrong, because there have been many central stations built for cotton mills.

Mr. Main. — Arrangements are left so that the warm water can be carried over to the mill yard at any time, but as the print works are being removed from their present location to a place about a mile and a half away, there would be very little use for warm water in the yard. The dye houses are to be moved also. There was no other vacant lot where this central station could be built, unless some of the tenements were torn down,

and that location would have been distant from the railroad and inconvenient for the handling of coal.

Mr. E. G. Scott. — I would like to ask why the central station in its present location could not transmit the steam for heating purposes. In the western cities the central heating plant has been carried out more extensively than it has around here, and they can carry the steam a long distance economically. Why cannot that be done in some of these central stations for mill work?

Mr. Main. — I do not know that I got the whole of your question.

Mr. E. G. Scott. — In regard to this question of exhaust steam, Mr. Gunby brings up the point that it is inadvisable to use it because you cannot get the destination near the supply. Why can you not transmit the steam further, say a half mile, and still use it for heating purposes?

Mr. Main. — It is transmitted that distance sometimes, but it did not seem advisable to do it at this particular place.

Mr. E. G. Scott. — I only made this point that it could be done economically where difficulties other than engineering do not arise.

Mr. Main. — It is done at the Wood Worsted Mill, for example. Low pressure steam is carried all around the yard, and it is about 2 000 ft. from one end of the yard to the other. There would be some complications in running the pipes through the streets in Lawrence. It was necessary to get permission of the Lawrence Gas Company to run wires over to the mill from the power station.

Prof. William L. Puffer. — I was very much interested in listening to the rather concentrated résumé of this power plant which is big enough to supply a dozen or so suburban stations. I want first to speak with respect to the way in which the transmission cables were placed in underground ducts. As I remember the description, it states that the cables were laid in the ducts two rows wide and eleven rows high, the idea being to get rid of the heat.

Mill power plants are not like electric light plants, which have a peak load of only a few hours, and practically all night for cooling, but they have instead a full load of nine hours per day. The resultant heating of the cables is far beyond that assumed as a basis for any of the published cables that can be found. The problem is one of convection of heat through and into the ground and there are few, if any, published data con-

cerning the rate at which heat in a duct line can be dissipated. The temperatures in duct lines of other plants are known to have risen to such values that the insulation of the cables is practically of no avail against puncture voltage, but slightly in excess of the normal operating conditions.

Three kinds of insulation — rubber, paper and cambric — are used for insulating cables, and as the temperature rises to a point not unduly high, the insulation resistance will fall to a point where the engineer would certainly be alarmed if he were fully aware of the facts. There is one good way of removing this heat, namely, installing the cables in the river or canal, or else diverting a part of the water through the ducts, and in this way removing the heat. In some duct lines with which I am acquainted the temperatures now rise toward the end of the day to a point at which the insulation resistance falls so low that the cables would never have been installed if such a value could have been predicted. In some duct lines where cables have been installed with a density nearly five times as great as used at the Pacific Mills, the inner ducts are useless.

Regarding the question of connecting the water wheels electrically to the transmission system, it seems to me that it would have been better to have installed induction generators, and so saved complications and expense in switchboards and in instruments, as the only thing required for connecting these generators to the line would be a starting compensator which would automatically produce phasing and prevent any possibility of a current rush upon closing switches on the line. If there was water, power would automatically be given to the line, and if there was no water, there would be no water given out. The only safety devices required would be an excess speed governor of some type and an overload device on the compensator.

Mr. Main. — That is practically the way the water wheels are hitched up and are run except that synchronous generators are used. One of these was used as a synchronous motor during the short period of time that the motors of the mill were underloaded and had a very poor power factor in order to help out the rest of the generating equipment. After that it was connected to the water wheels and run as generators are usually run. The water wheels for these generators are set at a certain gate opening to use the definite amount of water that the mill owes, and are provided with governors that will go into operation only when the speed of the wheels shall be increased, say five per cent. above the normal, all of the regulation being done from the steam

station. They require very little attention. Perhaps Mr. Gunby could tell us of the details in a more interesting way.

Mr. Gunby. — The use of asynchronous or induction generators for the water wheels, as suggested by Mr. Puffer, would have the advantage of not requiring anything like as close speed regulation as a synchronous generator. At the time this installation was put in, I had not reached the point where I felt like installing this type of generator and I am inclined to think I have not yet reached it. I am waiting for it to become more generally understood and used. I know this type has been used with low pressure turbines, and worked beautifully. When we installed this plant, we knew that we could get the older kind of generators to work pretty well, and I could not see sufficiently good reason for changing to the newer type, which for this service had some disadvantages, due to the generators having to furnish power at times when they might be the only apparatus on the line.

Professor Puffer. — Mr. Gunby neglects the opportunity of getting back at me by saying that asynchronous generators would require a magnetizing current which would have to come from the generator house where it would increase the lagging current of the system with a resultant decrease in the power factor of the plant. Of course any generator will have to have a magnetizing current which must be produced somewhere, and it is open to argument whether it would cost more to make it at the power house with large and efficient generators or to make it near the water wheels by small and inefficient exciters of a type requiring more or less attention and care.

Mr. Gunby. — I might say, in reply, that the way we start now is to throw them on the line which is dead at starting time. They have an arc lamp in the room from the alternating current night service about the mill, and the shadows on the pole pieces of the generators produced by the alternations of the arc itself make a pretty good kind of syncroscope. In starting up, the fields of those two generators are excited, the main switches closed, and the wheel gates opened sufficiently to bring the generators up to speed. They are of course then in synchronism, and the wheel attendant then regulates his gates so as to keep the generators in step with the arc lamp frequency. The engineer at the steam plant then synchronizes with this individual feeder and closes the switch. As the load comes on, the water-wheel man sets the gates at the prescribed opening, allowing the steam station to take the remainder of the load.

Referring now to the question of temperature of the duct line, I may say that while no extended test has been made yet, readings taken with a thermometer at the manhole entrance show maximum total temperature of about 38 degrees cent. This duct line at the time of the last readings contained about half of the ultimate cable capacity.

Mr. H. K. Rowell. — It seems to me that many interesting questions could be asked relative to the application of motors.

You probably noticed on the photograph the application of motors to the pickers, where the motor is placed on a bracket above the picker, and drives down to the beater by a belt. About a year ago we made another kind of application of motors to pickers by mounting the motor directly on the beater shaft. The frame of the motor is supported by a bracket bolted directly to the body of the picker, which required some very particular work. The bearing parts had to be machined so as to get exactly true bearings both parallel to and at right angles with the beater shaft. No skims were allowed.

Only one accident has occurred of which I have knowledge. One day a picker, or lap stick, happened to get on to the feeder apron while the machine was running and was fed into the beater, breaking the beater all to pieces. The motor did not stop. Other minor matters of no serious moment occurred incident to installing the apparatus. The damage caused by the picker stick seems to be the only objection, so far, to the direct-connected motors. If there had been a belt between the motor and the beater, the belt might have slipped off the pulleys before the beater was broken. This accident, however, was not in any way serious.

Another apparent objection to a motor direct connected to the beater, it seems to me, is the matter of speed. With the induction motor you are tied down to either 1 150 revolutions or 1 700 revolutions. With the mechanical, or belt drive, the beater usually runs from 1 200 revolutions to about 1 450 revolutions. It is not advisable to run the beaters as fast as 1 700 revolutions. I have known it to be done in two mills, but one of these mills afterwards reduced the speed. Eleven hundred and fifty revolutions may be a little too slow, but it has worked out very satisfactorily for the reason that the speed is very uniform, where the motor is mounted on the beater shaft, and the efficiency of the machine is better than with the old-fashioned method of driving. I know of one plant where one hundred and eighty motors are mounted on the beater shaft. The overseer

says that he gets just as much product at the slower speed as he used to get at a higher speed, that now his laps are cleaner and run more even in weight. In this installation the fans run as fast as they did before the motors were installed, and the calender rolls run as fast as they used to. The beater itself runs one hundred or more revolutions slower; the product is kept up by feeding in the cotton a little faster.

The fact that the beater can run slower, and the fan and calender rolls run as fast as they did before the motors were applied would tend to resolve the question in favor of the slower speed for the beater, as there is less liability to injure the fiber. Injury to the fiber is the principal objection to the high speed of the beater.

Another factor that enters into this question of beater speed is the weight of lap it is desired to make, although this question of weight can be regulated by the draft of the machine independently of the speed of the beater, as in the case cited.

The mill to which I referred first placed the motors for one set of pickers on the ceiling and drove by belts from the motor to the beater, so they could get varying speeds if they wished.

As time goes on it will be interesting to watch the development of the methods of application. If the mills are going to adopt generally the method of mounting the motors on the picker beaters it will force the machinery builders to make better machines. The question of beater speed can be adjusted by making the beater of larger diameter so that the peripheral speed will correspond to the speeds now in general use.

So far as I have observed, the direct connected motor on the beater shaft has worked out satisfactorily. One mill with which I am intimately acquainted has thirty-five motors, and another plant I mentioned above has one hundred and eighty motors, the last eighty motors having been ordered and installed two years later than the first order was placed.

Mr. G. A. Burnham. — I would like to ask what kind of cables are used, — whether triple or single conductor.

Mr. Gunby. — They are triple conducted cables, with varnished cambric insulation, — all lead covered.

Mr. Burnham. — I had an opportunity to investigate the heating of cables in a 9 by 9 duct system, the results of which were very interesting and instructive. I cannot remember the exact figures, but the variation of temperature of the duct (if I remember rightly) showed an increase of 10 degrees cent. from the outer layer of ducts to the center. This temperature rise

was at 2 watts loss per duct foot. The curve showing the increase of temperature in the ducts as they were removed from the earth was practically a straight line and sloped off very slightly towards the center. The duct line in question being a 22-duct line, I would like to know if you have an idea where the hottest portion of that duct system is located.

Mr. Gunby. — As I remember, the temperature is fairly uniform all the way through. We have not made any very careful tests.

Mr. Burnham. — In the 9 by 9 duct system which I mentioned the hottest part of the system was in the central layer slightly above the center duct. We carried on experiments to determine the hottest point in the duct line, longitudinally. One would naturally think it would be toward the center, but tests indicated that the hottest portion may change with atmospheric changes and that one day it might be in one place and another day in an entirely different place. The hottest portion of the duct system on a 200-ft. run between the manholes was about 30 ft. from one of the manholes, showing that the air sweeping through the duct line carried the temperature with it and piled up so that the temperature was maximum at that point. In connection with Professor Puffer's statement about the intermittent load, we took measurements to determine whether the temperature would go back to normal when the plant was shut down at night and not starting until the next morning. For seven days the curve of temperature rise was a saw-tooth shaped curve increasing each day. We did not carry it far enough to get to the constant temperature point. We attempted to operate the duct line at 3½ watts per duct foot, but found it was impossible to do so on account of the excessive rise of temperature on the cables in the central portion of the duct. Engineers lay great stress on the proper radiation of underground cable systems in order to keep the heat within proper limits, but when their specifications are furnished for an installation of cables, in many cases with which I have come in contact I find that where triple core cables could not be satisfactorily placed in the standard ducts they installed single core cables and placed them as closely together as possible, mounting them on metal brackets. Furthermore, these cables are generally bonded to prevent electrolysis, and when such conditions exist it is generally found that a great deal of heat in the duct system is caused by sheath currents. We carried on further experiments to find out how much current flowed

in cable sheaths, using a million circular mill cable 16 ft. in length, folded back so as to make a loop 8 ft. long. With 900 amperes flowing in the copper, and the sheath short-circuited through the ammeter, we got, if I remember rightly, about 200 amperes flowing in the lead sheath. Plotting the temperature rise after the sheath was short-circuited, the temperature increased in the improvised duct which surrounded the cable 18 degrees cent. That increment of rise was due simply to sheath current.

Mr. C. M. Green. — Lead covered cables ordinarily have in them one or more electrical conductors, and in the case of the current flowing in one conductor under a lead sheath, the lead sheath is in very close proximity to it, so that it is interlinked with the magnetic field produced by current flowing through the conductor, thereby inducing an electro-motive force in this lead sheath; and if the circuit is long the voltage induced in this lead conductor may be high, sufficient to produce arcing and heating where it may come in poor contact, or in moving contact with other conductors, — arcing in certain instances sufficient to ignite explosive gases, causing explosions in manholes, or even burning the lead covering, and possibly burning through the insulation, producing a breakdown in the cable if the lead covering on the cable is not made a complete metallic circuit, so as to prevent this arcing. In certain instances, if the fluctuations in the current are excessively violent, as in the case of short circuits, etc., the voltage loss in the cable may be very high, and the potential difference generated in the lead covering is in opposition to that generated in the cable; as a result the voltage may be sufficiently high to break down the insulation of the cable. In other words, particular attention should be paid so as to thoroughly ground, preferably short circuit, the lead covering on any cable carrying a single conductor, so that it will be a complete metallic circuit. This, of course, in certain instances means a considerable loss of electrical energy and heating in the cable cover, which can be overcome entirely when the construction is such that the outgoing and returned circuit can be under the same lead covering. These currents being in opposition to each other, no appreciable magnetic field is produced; accordingly, no electro-motive force induced in the lead covering of the cable so that heating, etc., is absent; accordingly, when lead covered cables are used on either single phase or poly-phase circuits the construction should be such that the outgoing and returned circuits are under a single lead covering, and if for any

reason the amount of current to be carried is so large that it is prohibitive to get two or three conductor cables which will carry this energy I would suggest and consider it very much better to have two or three phase cables connected in parallel so as to overcome the induction and current which would be generated in the lead sheath which acts practically the same as short-circuited secondary of a series transformer.

There are certain instances, for example, on series arc lighting circuits, where it means a large additional expense to put the outgoing and returned circuits under the same lead covering; in these cases, the lead covering on the cables should be thoroughly bonded together and grounded so as to form a complete circuit.

Frequently at the present time wires are run in iron pipes. If they are carrying alternating current particular attention should be paid to get the outgoing and returned circuits inside of the same pipe so as to neutralize each other and eliminate what would otherwise be excessive induction, iron losses, heating of the tube, etc.

Mr. Burnham. — I might add that we found it necessary to take all bonding off the cables so that it absolutely eliminated any closed circuit on induced current. When this was done the static piled up enormously on the sheaths. To overcome this the cable sheaths were grounded at the ends through a resistance of about 400 ohms. The static was entirely eliminated and the temperature reduced, allowing more cables to be used in the duct system with the ultimate temperature lower than before. Regarding the breaking down of cables, after careful investigation we found that the failure took place at some point where the sheaths touched each other, or where the sheath had been placed in the metal rack. At these points there seemed to be a condition similar to that due to electrolytic action which practically ate away the lead sheath and caused the lead to become very porous, and many times on a very slight movement of the cable the sheath would break open. From what I can learn the changes in the system were very beneficial.

Professor Puffer. — At the risk of taking up a little too much time I want to refer to the installation matter that has been mentioned in our discussion. It seems to me that here is an engineering mistake in making a duct line 9 by 9. The results are understood to have been so odd or strange that a great many experiments were carried on. The results of those experiments seem to have been suppressed, so that as engineers

we are not benefited by the lessons of that duct line. I believe that engineers learn as much by failures and by negative results sometimes as by success and by positive results. I have accidentally seen blue prints and curves from that system. Officially I have not seen them at all, but I do know from what little has leaked out and what I have heard to-night that there is a great deal of information to be had upon that famous 9 by 9 duct line if the engineers who have it would only let it out as common information; and I think these things ought to be said by engineers in an engineering meeting. It does not hurt anybody. Probably about three ducts all the way around are useful.

MR. BURNHAM. — I want to correct any misunderstanding that may arise. Although I made practically all the tests, I did not design the duct line.

[NOTE. — Discussion of this paper is invited, to be received by Fred. Brooks, Secretary, 31 Milk Street, Boston, by March 15, 1912, for publication in a subsequent number of the JOURNAL.]

POWER FOR COBALT MINES, COBALT, ONTARIO.

By Cecil B. Smith, Member Can. Soc. C. E.; M. Am. Soc. C. E.; M. Inst. C. E.; M. Oregon Soc. Engineers.

[Read before the Oregon Society of Engineers, May 11, 1911.]

Until quite recently the silver production of Canada was chiefly confined to British Columbia, but the phenomenal and rapid growth of the Cobalt camp has increased the production until it is now the third most important silver-producing country of the world. The Canadian output in 1908 was 22 000 000 oz., in 1909 27 000 000 oz., and in 1910 33 000 000 oz. (15 per cent. of world output), of which Cobalt produced 29 000 000 oz. The growth of the Cobalt output alone from 30 shipping mines is shown by the following table.

	Tons.	Value.
1904	160	$135 000
1905	2 400	1 485 000
1906	5 800	3 570 000
1907	14 800	6 155 000
1908	25 400	9 133 000
1909	30 000	12 356 000
1910	34 000	14 500 000

The writer was chairman of the Ontario Government Railway Commission, then constructing a railway from North Bay, Ontario, through the Cobalt camp northward toward the Hudson Sea during 1905 and 1906, and was frequently consulted regarding the suitability of an investment for supplying the camp with power. But he then considered that the camp was not yet firmly enough established to warrant a large power investment. However, in 1907 the permanency of the camp was better demonstrated and by 1908 several power projects were being actively exploited.

The natural and evident sources of power were the upper Ottawa River (Quinze), on which large and, therefore, expensive developments could be made, and the Montreal River, a smaller stream rising west and south of Cobalt and flowing into the Ottawa River, and passing within eight or ten miles of the camp, and on this river two of the developments to be described have been constructed; whilst somewhat further south, but

within twenty-five miles of the main Cobalt camp, is the falls of the Matabetchouan River, where a third development has been constructed.

In 1908 the writer's firm carefully canvassed the camp for power data and found 13 000 h.p. boilers then installed and power being chiefly produced by Pennsylvania coal, costing $6.00 per ton at the bunkers, and as the power plants were mostly small and crude, the cost of power ranged from $75 per h.p. per year for suction gas producer power to $150 per h.p. per year for power produced by small isolated steam plants, and the power was largely devoted to air compression, although since the camp has been supplied with electric power at $50 per h.p. per year, about 20 concentrators have been erected.

(1) Cobalt Power Company Plant.

This plant is on the Montreal River at Hound Chute, distant seven miles from Cobalt, and generates and transmits power at 11 000 volts, 60 cycles. It has converted a natural fall of 17 ft. to 35 ft. by a concrete dam and power house. The minimum flow of the river is 800 cu. ft. per sec., and as the pondage for peak loads is excellent, extending several miles up the river, the installation of four 1 400-h.p. hydraulic units was justifiable. These are vertical single runner turbines direct coupled to 875 K. V. A., 150 rev. per min., 11 000 volt generators, which have revolving fields supported by ball thrust bearings on top of the machines, which have gravity oil feed. The turbines have their own thrust bearings, and the couplings between the generators and turbines are flexible.

The designs and construction are Canadian, except the generators and governors, the former with two 60 kw. exciters being supplied by Allmænna Svenska, of Sweden, and the latter by Riva, Moneret & Co., of Milan, Italy. The power is transmitted by a double-circuit 11 000 volt pole line and taken direct to various customers, at whose premises individual substations of from 50 h.p. to 600 h.p. each are placed. This system went into operation April, 1910, and is fully loaded; in fact, in February, 1911, Cobalt camp suffered from a shortage of power due to extreme low water conditions.

(2) Cobalt Hydraulic Power Company Plant.

Mr. C. H. Taylor, of Montreal, is the first engineer to adapt to practical modern use the ancient Spanish trompe, and by his

installations at Magog, Quebec, in Maine, at Rockland, Mich., in British Columbia, and now at Cobalt, Ontario, has arrived at a refinement of result which is most gratifying.

The working efficiency is now safely taken at 75 per cent. of the theoretical hydraulic capacity, and the compressed air obtained is pure and dry.

The location of this Cobalt plant is also on the Montreal River and about nine miles from Cobalt. Under 50 ft. head the air h.p., with a minimum of 800 cu. ft. per sec., is about 3 500 continuous, but the capacity to deliver under ordinary working conditions is well up to 5 000 h.p. maximum. The air in the subterranean chamber is at 125 lb. and is delivered to the mines at 100 lb. by means of a 20 in. seamless flanged air main manufactured in Germany.

The distributing mains step down from 20 in. to 12 in. and 6 in. and are carried in rings or loops from mine to mine, as a factor of safety.

The intakes consist of 132 pipes, 14 in. diameter, slightly submerged in water, and as the water rushes inward and downward through two 9-ft. diameter vertical penstocks, the air is entrained in bubbles.

These downtake penstocks extend 350 ft. into the earth and then expand to $11\frac{1}{2}$ ft. diameter. As the water passes horizontally toward the uprising tailrace, there is excavated a chamber into which the compressed air escapes and from which it is drawn to the mains. There are some evident automatic devices, such as air operated level of the 14-in. intake pipes, so as to keep them submerged just the depth required to draw in the most air, and automatic blowoffs, which operate when the air chamber is filled with compressed air not being taken away to the mines.

This plant is designed to handle 40 000 cu. ft. free air per minute, and will deliver 5 000 cu. ft. compressed air per minute at 125 lb., which is sold at 25 cents per 1 000 cu. ft., giving a revenue of $1.25 per minute at full output. It is safe to estimate the actual yearly revenue at $350 000 per year, which will pay for the plant in three years, as the cost of operation and repairs when the plant is once successfully installed is practically negligible.

This plant went into operation in May, 1910, but later in 1910 leakage developed in the air chamber, and the plant was shut down and the chamber lined with concrete. The operation is now normal, and, it is understood, continuous.

(3) British Canadian Power Company's Plant.

In the winter of 1908–9 the writer negotiated a lease of the water rights of the Matabetchouan River where it falls some 300 ft. near its entrance into the Ottawa River (Lake Temiskaming). In the spring of 1909 the company commenced construction, and although struggling against severe climatic and transportation difficulties, was able to go into operation in April, 1910.

The details of this plant are minutely set forth in a paper * read before the Canadian Society of Civil Engineers, January, 1911, at its annual meeting, by members of the staff of Smith, Kerry & Chace, who designed and built the plant; but it is interesting to note that the company (in order to compete with the compressed air output of the Cobalt Hydraulic Power Company's plant) constructed at its Cobalt and Brady Lake substations air compressor stations having compressors driven by electric motors. The air compressor capacity is about 4 000 h.p. in 4 units, but considering one unit as a spare, the capacity is 15 000 cu. ft. free air per minute, or 2 200 cu. ft. of air at 100 lb., which sells at approximately 50 cents per minute, or say $200 000 per year, equivalent to nearly $70 per h.p. continuous delivered substation power. The hydro-electric plant capacity of 8 000 h.p. continuous, or 11 000 h.p. peak generating capacity, is already fully sold and the power market is not satisfied.

However, as the life of the camp is uncertain and not estimated at more than fifteen years from date, it is, therefore, not likely that any further developments will be made, unless additional and new territory adjacent is found to warrant a longer future.

[Note. — Discussion of this paper is invited, to be received by Fred. Brooks, Secretary, 31 Milk Street, Boston, by March 15, 1912, for publication in a subsequent number of the Journal].

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* "Hydro-electric Power Development of the British Canadian Power Company," by A. L. Mudge, A. M. Can. Soc. C. E.; N. R. Gibson, A. M. Can. Soc. C. E., and S. M. Waldron.

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THE NEW SAND-DRYING PLANT OF THE UNITED RAILWAYS COMPANY OF ST. LOUIS.

BY C. L. HAWKINS, MEMBER OF THE ENGINEERS' CLUB OF ST. LOUIS.

[Read before the Club, May 17, 1911.]

ABOUT March 1, 1911, the United Railways Company completed the construction of a new plant for drying the sand used in the boxes on the cars. The amount of sand used depends upon the condition of the rail and it is absolutely necessary that the sand be dry and free from gravel in order to flow freely from the boxes. The company operates about 1 400 electric cars, and the total track mileage in the city and county is 474 miles, 114 of which is unpaved T-rail construction in private right of way. The average track grade is about 2½ per cent.

The amount of sand used per month varies from about 300 cu. yd. during the dry summer months to 1 300 cu. yd. during the winter months, the total for the year being about 6 000 cu. yd. All of this sand is dried at the one plant and delivered to bins, holding about 35 cu. yd. each, located at the car barns and at various places along the tracks. There are 34 of these small bins and their total capacity is 1 400 cu. yd., or about one winter month's supply. The sand used is ordinary Mississippi River bar sand dredged by the Union Sand and Material Company and contains considerable gravel and from 3½ per cent. to 5 per cent. of moisture when it arrives at the drying plant.

The first central drying plant built by the St. Louis Transit Company was located near the power house at the Park and Vandeventer yards. At this plant the wet sand was shoveled by hand from steam railway cars into a shallow bin, in the bottom

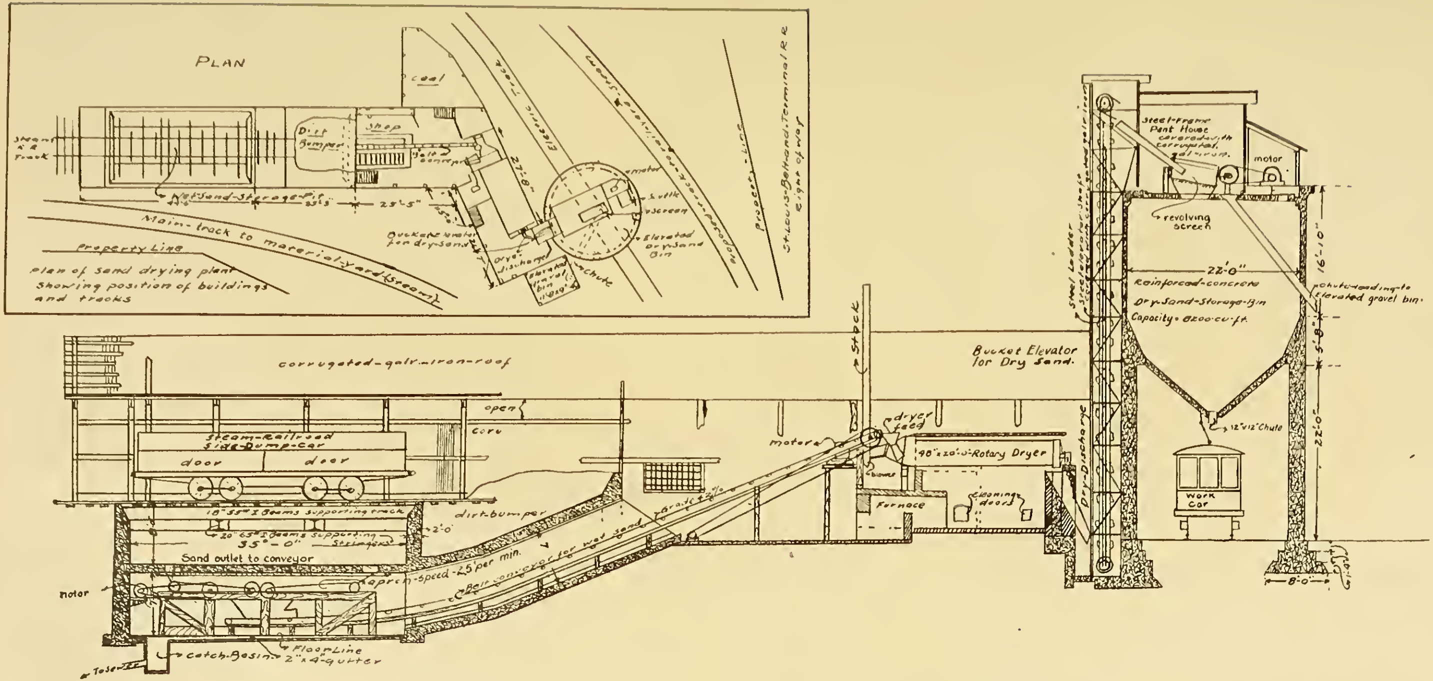
of which there was a system of steam pipes heated by exhaust steam from the power house. An inclined screen located above these pipes separated the gravel from the sand by allowing the sand to fall into a screw conveyor which carried it to a bucket elevator leading to an elevated bin. The gravel was removed by hand through openings at the lower end of the screen.

This method of drying did not prove satisfactory and the capacity of the plant was not sufficient to supply the demand, so the drying was then done with six "Champion" sand-drying stoves, fed by hand, the sand being shoveled from the cars into piles near each stove. The dry sand was wheeled from these stoves to the old elevators which carried it to the elevated bin. A revolving screen was placed above the bin to separate the gravel from the sand. The cost per cubic foot of dry sand by this plant was as follows: Labor, 1.5 cents; coal, 0.27 cents; freight, 0.74 cents; sand, 1.3 cents; interest, depreciation, taxes, etc., at 16 per cent., was 0.59 cents; total, 4.5 cents. The amount of moisture evaporated per pound of coal was $1\frac{1}{4}$ lb.

After the elevated bin was destroyed by fire about June 1, 1910, the dry sand was wheeled up a runway and dumped directly into work cars. The cost of labor per cubic foot of dry sand was increased to 1.84 cents, and the cost for interest, depreciation, taxes, etc., was reduced to approximately 0.005, making the total cost about 4.155 cents per cubic foot. This plant could not have supplied the demand for dry sand even during the winter, though the work was carried on night and day, so the design of a new plant was started at once.

The location selected was on a tract of land near the Suburban Garden at the western city limits, where it was also proposed to locate a new supply yard suitable for handling all of the material required by the track department. This yard is on the south side of the Inner Belt Line tracks of the Terminal Railway Association and the switching charge per car is three dollars less than at the Park and Vandeventer yard, which is located on the St. Louis and San Francisco railroad tracks. As it was necessary to do quite a large amount of grading before the entire lot could be shaped for tracks, the sand plant was placed at the north end where very little track work was necessary to put this plant in operation and where valuable storage space was not utilized.

The cross-section of the plant shows the course of the sand from the time it is dumped from the Union Sand Company's side-dump steam railway cars until it falls from the elevated bins into the work cars ready for the distributing bins.

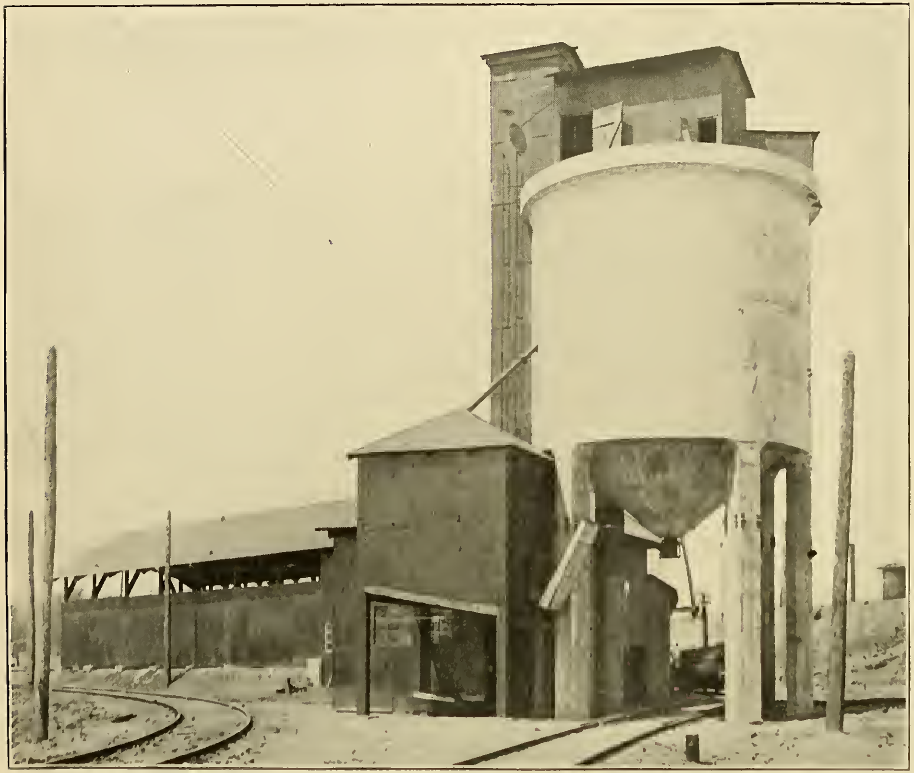


CROSS-SECTION OF SAND-DRYING PLANT DEVELOPED ALONG CENTER LINES OF PIT, DRYER, ELEVATOR AND SCREEN. SEE PLAN ABOVE FOR TRUE POSITIONS.

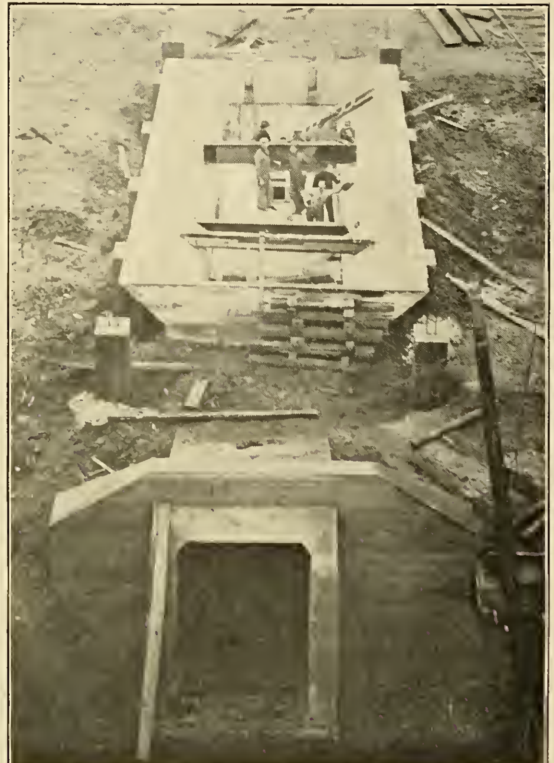
The wet sand is dumped directly into the wet sand pit. Two apron conveyors carry it from the openings in the bottom of the pit and deliver a uniform flow of sand to a belt conveyor leading to the rotary dryer. This dryer consists of a revolving steel cylinder 4 ft. in diameter and 20 ft. long, supported above a hand-fired furnace burning slack bituminous coal. The center line of this cylinder is set on a grade of about $\frac{1}{2}$ in. per ft. The sand is received at the upper end and is tossed about by six curved lifting blades while an exhaust fan draws the hot gases around the cylinder and then into it through openings in the periphery, thus bringing the hot gases in direct contact with the sand as it travels toward the lower or discharge end of the dryer. A bucket elevator conveys the dry sand to a revolving screen located on top of the reinforced concrete bin. From this screen the sand falls directly into the bin and the gravel passes through a chute leading to an elevated gravel bin.

The wet sand pit was designed to hold about 3 000 cu. ft., or about two days' supply; 1 500 ft. of this will slide into the openings with little or no shoveling. The conveying machinery below required a space about 10 ft. wide, so the pit was made the same width, with the sides sloped back at the top to catch the sand as it falls from the side-dump cars. The floor of the pit is 13 in. thick and is reinforced with $\frac{3}{4}$-in. square rods 6 in. apart. The walls of the pit are 2 ft. thick and are not reinforced. The sloping sides were reinforced with $\frac{1}{2}$-in. square rods 12 in. apart, more for use in case of derailment of cars than for sand loads, as the sides are supported by a dirt backing. The four sides of the tunnel leading from the machinery room were made 15 in. thick and reinforced with $\frac{3}{4}$-in. square rods 9 in. on centers. The dirt bumper on top of this tunnel is at the foot of a 2 per cent. grade, 1 200 ft. long, and on account of the damage that might result from careless switching, the tunnel was made considerably stronger than the dead or live loads required. For temperature reinforcement $\frac{1}{2}$-in. square bars were used in the reinforced parts of the pit and tunnel.

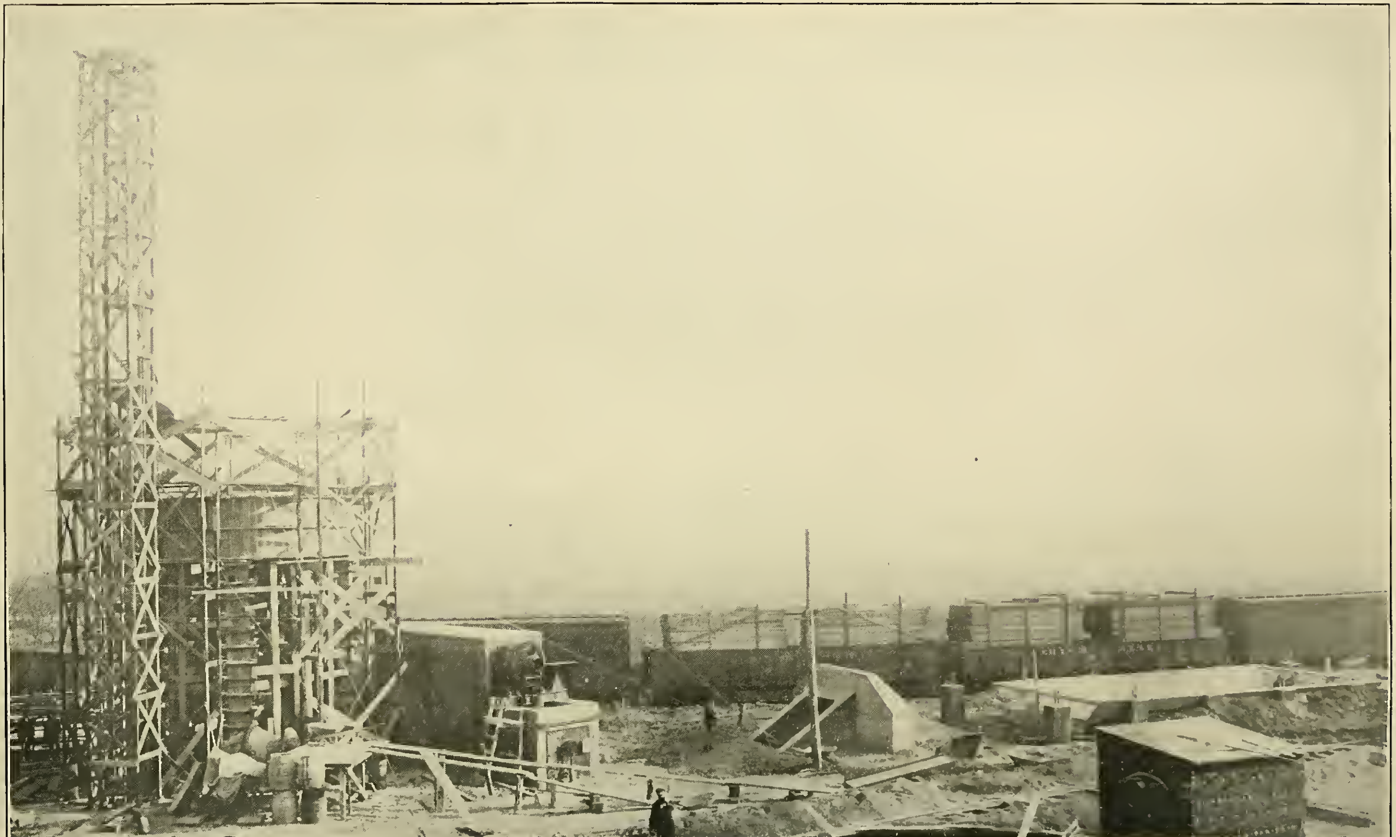
In the design of the dry sand bin holding 8 200 cu. ft., fluid pressure at 100 lb. per cu. ft. was used in computing the side and bottom reinforcement. The circular beam between the posts at the bottom of the bin was designed to hold four tenths of the total sand load, but the conical bottom was designed for full load. The vertical side walls of the bin are 7 in. thick, and the ring reinforcement increases from $\frac{3}{8}$-in. square bars 12 in. on centers at the top to $\frac{3}{4}$-in. square bars $6\frac{1}{2}$ in. on centers at the



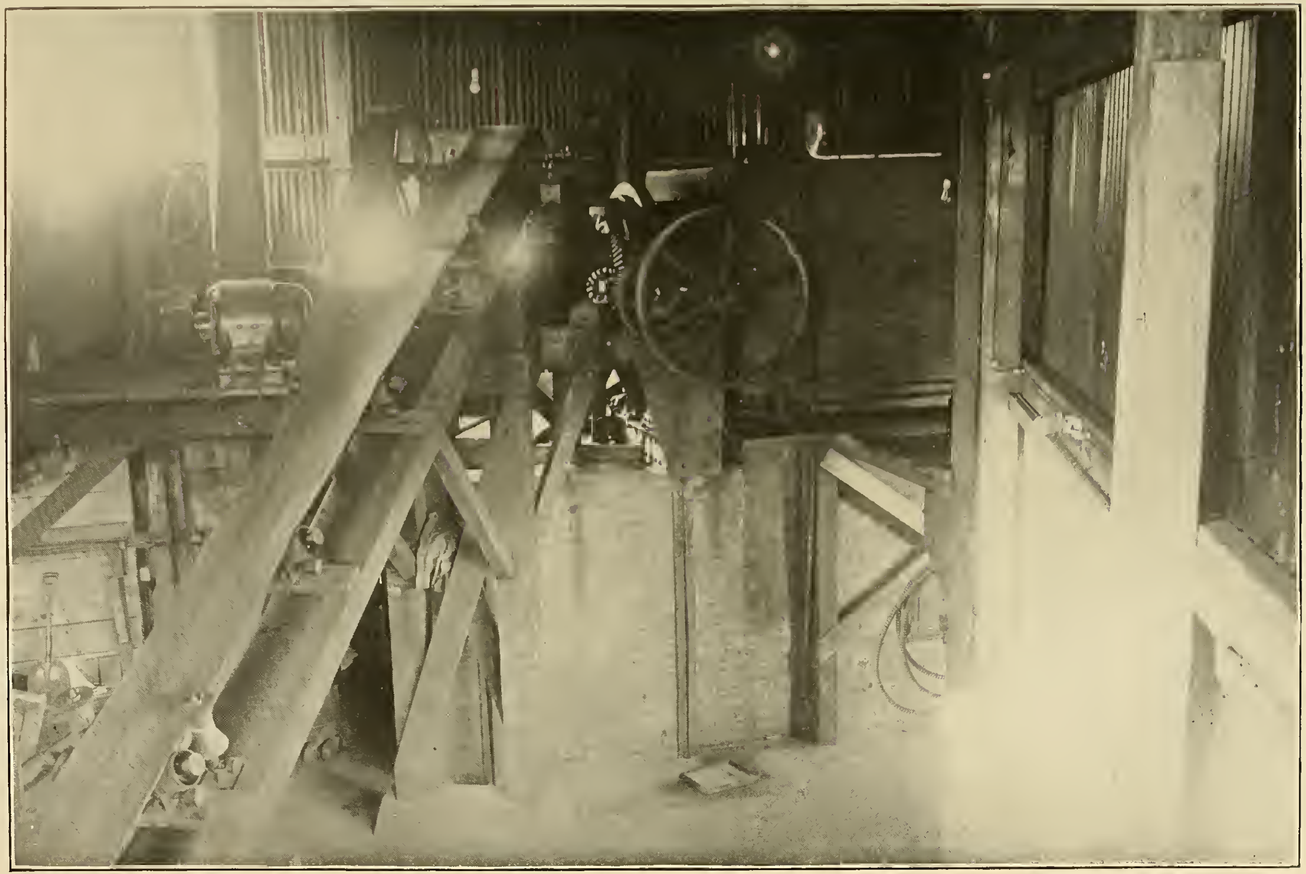
Completed Plant, showing steam-track leading to material yard and electric track under Dry Sand Bin, also elevated Gravel Bin.



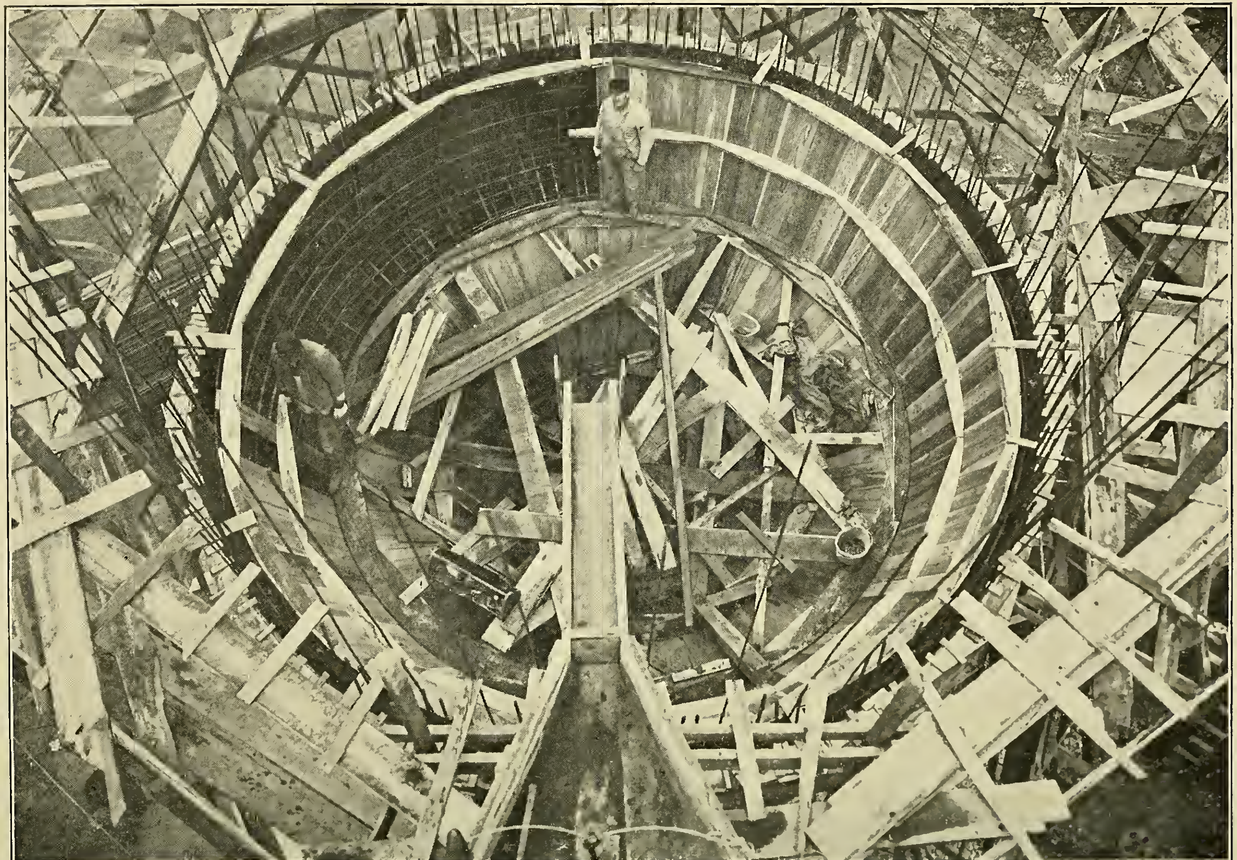
Wet Sand Pit and Tunnel for Conveyor Belt (from top of Dry Sand Bin).



Dry Sand Storage Bin, Rotary Dryer, Outlet of Tunnel and Wet Sand Pit, during construction.



Wet Sand Conveyor Belt and Front of Rotary Dryer and Furnace.



Forms and Reinforcement in Conical Bottom of Dry Sand Storage Bin, looking down from top of tower of concrete elevator. Concrete chute in foreground.

bottom. Vertical temperature rods are $\frac{1}{2}$-in. square bars 18 in. apart. The conical bottom is 9 in. thick with ring reinforcement varying from $\frac{3}{4}$-in. square bars $6\frac{1}{2}$ in. apart to $\frac{5}{8}$-in. bars 9 in. apart. The radial reinforcement in the bottom consists of one hundred and twenty $\frac{3}{4}$-in. square bars, thirty of which run to the opening at the bottom, while the others stop at the $\frac{1}{4}$, $\frac{1}{2}$ and $\frac{3}{4}$ points. The circular beam is reinforced with eleven 1-in. square bars, seven of which are at the bottom. The roof was made 9 in. thick with reinforcement running both ways. The columns are 24 in. thick with $\frac{1}{4}$-in. square hoops 12 in. apart and eight $\frac{3}{4}$-in. square vertical bars; the opposite center bars are tied together with No. 12 wire and all vertical bars are embedded about 40 diameters in the circular beam and also in the ring foundation.

All of the construction work was done by the building and mechanical departments of the company. Machine mixed gravel concrete of 1:2:4 mix was used where reinforcement was required and 1:3:5 for the plain concrete. The water for the concrete was supplied by a track sprinkling car equipped with an air compressor for lifting the water to the mixer.

In the construction of the dry-sand bin the ring foundation was poured at one time, then the posts up to about the $\frac{3}{4}$ point. The inside and outside forms for the lower part of the circular bin, up to the 7-in. wall, were built on the ground in sections. After the entire lower or inside form had been placed, all of the rods, except those in the roof and the ring reinforcement in the 7-in. wall, were placed and securely fastened with wires or with nails and small concrete blocks. The inside form was then placed and anchored to prevent floating. After this section was concreted the side walls were poured in three sections, moving the same forms up about four feet each time. The roof and the last of these sections were poured at one time.

The gravel bin was built of wood, as was also the frame of the building surrounding the dryer and the wet-sand pit. The frame of the elevator tower and the screen house on top of the dry-sand bin were made of 3-in. by 3-in. by $\frac{3}{8}$-in. angles. All of these buildings were covered with corrugated galvanized iron.

The conveying and screening machinery was furnished by the Link Belt Company. The two apron conveyors consist of $\frac{3}{16}$-in. steel overlapping corrugated pans 9-in. pitch and 18 in. wide attached to a steel bar link chain supported on rollers. The 14-in. conveying belt is made of 4-ply rubber belting with $\frac{1}{16}$-in. rubber covering and carries the sand up a 42 per cent. grade very satisfactorily. The bucket elevator consists of 7-in.

by $4\frac{1}{2}$-in. by 4-in. malleable buckets 12 in. apart on a 4-ply rubber belt. The screen is 36 in. in diameter and 6 ft. long, with $\frac{3}{16}$-in. openings between the wires in the covering. The conveyors, etc., are operated by four motors.

The cost of the buildings and machinery for this plant was approximately $14 000. The plant is operated by two or three men (from one of the car houses), depending on the condition of the sand; these men unload the cars, fire the furnace, watch the moving parts and keep them properly oiled, and keep the plant clean and in good order. On one of the first tests before the machinery speeds were properly adjusted the following results were obtained.

Moisture, 4 per cent.	
Length of tests, 18.8 hr.	
Cubic feet of sand dried, 2 650.	
Pounds of coal used, 4 340.	
Power used, 240 kw. hr.	
Weight of water evaporated per pound of coal, 2.45 lb.	
Tons of sand dried per hour, 7.05.	
Tons of sand dried per ton of coal, 61.	
Cost of operating machinery per cu. ft. of sand,	$0.0044
Cost of power per cu. ft. of sand,	0.0009
Cost of coal per cu. ft. of sand,	0.0016
Sand and freight per cu. ft. of sand,	0.0172
Interest, depreciation and taxes (12 per cent.),	0.0104
Total,	$0.0345

After this test the dryer speed was increased and a new test made. The sand at this time contained $3\frac{1}{4}$ per cent. of moisture.

The length of test, 13.5 hr.	
Cubic feet of sand dried, 3 200.	
Pounds of coal used, 4 400.	
Power used, 300 kw. hr.	
Weight of water evaporated per pound of coal, 2.55 lb.	
Tons of sand dried per hour, 11.84.	
Tons of sand dried per ton of coal, 73.	
Cost of labor per cu. ft. of sand,	$0.0026
Cost of coal per cu. ft. of sand,	0.0012
Cost of power per cu. ft. of sand,	0.0009
Cost of sand and freight per cu. ft. of sand,	0.0172
Interest, depreciation and taxes (12 per cent.),	0.0104
Total,	$0.0323

During the coming winter it is expected to decrease this cost considerably.

The total cost of drying 6 000 cu. yd. of sand by the stove method, including the cost of maintenance, etc., of the necessary dry-sand storage bin, would amount to about $7 290 per year. The total cost of drying at the new plant, figured at $0.0323 per cu. ft., is $5 232.60, a saving of $1 957.40 per year, $510 of which is due to the saving of $3 per car for switching charges.

[NOTE. — Discussion of this paper is invited, to be received by Fred. Brooks, Secretary, 31 Milk Street, Boston, by April 1, 1912, for publication in a subsequent number of the JOURNAL.]

DEVELOPMENTS IN THE ILLINOIS OIL FIELDS.

By H. A. Wheeler, Member of the Engineers' Club of St. Louis.

[Read before the Club, March 15, 1911.]

Historical.

Prospecting for oil and gas in Illinois has been carried on more or less spasmodically since the first great oil excitement in the early sixties. Although the drilling was shallow, or less than 1 000 feet in depth, it resulted in finding slight amounts of oil and gas in eastern Illinois in Clark and Crawford counties, while in western Illinois oil and gas were found at Litchfield and gas at Sparta of modest commercial value. Up to the latter part of 1904 the results had been so discouraging that most oil operators had given up all hopes of developing lucrative fields in either the eastern or western portions of the state. Yet the geological structure of Illinois was known to be most favorable for expecting profitable oil fields, and notwithstanding the considerable unfavorable results of the drill, a few mining engineers were enthusiastic as to the petroleum future of the state. Nor was this optimism dimmed by the skepticism and failures of the oil prospectors, as the amount of drilling was entirely inadequate to justify the sweeping condemnation that most oil men passed on Illinois in 1904.

Eastern Illinois. — In 1904 an old oil operator, Mr. J. J. Hoblitzell, had the courage to again prospect in eastern Illinois, near Casey, where unprofitable drilling had been carried on more or less erratically for forty years. His work resulted at first in a few wells that were so small as to not encourage other oil men when leases were obtainable for $5. to $10. an acre. The subsequent bringing in of a 40-barrel well, however, removed their skepticism and started energetic prospecting that has continued ever since. This resulted in the bringing in of quite a number of wells, which while not large, or usually ranging from 10 to 50 barrels, enabled eastern Illinois to close the year 1905 with a total shipment of 181 084 barrels. Oil leases rapidly advanced in value and sold for $100. to $250. per acre for virgin or undrilled land when favorably located, while the oil royalty advanced from the usual $\frac{1}{8}$ to $\frac{1}{6}$ and even $\frac{1}{4}$ of the output.

The southern extension of the Casey field was opened up in the following year along the geological deformation known as the La Salle Anticline in Crawford County, near Robinson. While the wells were deeper, they were so much richer that the further extension of the field to the south along the anticline soon followed, and by 1907 the Bridgeport or Lawrence County field had been developed, which is the deepest and by far the richest in the state, if not the most lucrative ever opened in the history of this profitable industry.

Oil operators were attracted from all parts of the country by the richness of the new field, and so rapid was the development that the output in its second year (1906) was 4 397 050 barrels, 24 281 973 barrels in 1907, while in 1908, its fourth year, it reached the unprecedented production of 33 685 106 barrels.

Comparison with Other Fields. — Such an enormous output in such a short time has never before been attained in the history of the industry. It requires time, as well as money, to follow up and develop a new oil field, and the older oil-producing states have never approached such a brilliant record. The largest annual output of Pennsylvania, where the industry was born in 1859, was 31 330 021 barrels, and it required thirty-two years before this maximum was attained. Ohio ranks second in importance to Pennsylvania, and it took twenty-one years before this state reached its zenith production of 23 941 109 barrels. The other important producers, or West Virginia, Indiana, Texas, Oklahoma and California, have taken fifteen to fifty years to attain their maximum output. The future prospects for Illinois are therefore exceedingly brilliant, judging by the record of all its predecessors, for greatly exceeding its present very large output when sufficient time has permitted the discovery and development of the virgin pools that are yet untouched, especially in the western part of the state. That there is little doubt of a further increase in the output of Illinois is indicated by the past two years' output. For although the output of 1909 was 30 898-339 barrels, which was a decrease of about ten per cent., this was largely due to the inability of the tank lines to handle the oil, rather than to the usual sharp shrinkage that generally follows flush or new production. On the completion of two more pipe lines in 1909, the output of 1910, or the sixth year, rose to 35 000 000 barrels, a new high record that firmly intrenches Illinois as the richest and most prolific "youngster" in the industry.

Description of the Eastern Illinois Field.

The eastern Illinois oil field extends southwest from Westfield, in the northern part of Clark County, through Crawford and Lawrence counties, Illinois, to Princeton and Oakland in Gibson County, Indiana. There are slight lateral extensions to the westward in Coles, Cumberland and Jasper counties.

It has a length of 90 miles and a width that varies from 1 to 10 miles and averages 3 to 4 miles. A few gaps still break the continuity, although these have steadily diminished in size and number as the field is redrilled with greater care. Such a remarkable length and width, coupled with the richness and number of oil-producing sands already found, without considering deeper pays that geology almost assures, makes this the richest oil field ever opened in the history of the industry. While individual wells and local enrichments in other fields have exceeded the Illinois record, no other field has shown such a *high average richness* over such a remarkably large area, nor have they ever reached an output of 35 000 000 barrels in six years.

Casey District.—At the northern end, or Casey District, there are two producing sands at about 400 and 600 feet, and the belt is two to five miles wide. While the wells have not been large, the drilling is so inexpensive that it has proved highly profitable. Like most shallow sands, they are not proving long-lived, and new work had nearly ceased until a recent discovery was made at about 2 900 feet. The latter is the deepest production in Illinois, but it is too early to determine its magnitude.

These shallow wells cost $800. to $1 200. completed, which includes the drilling, casing, shooting, tubing, tankage, pumps, etc.

Crawford County District.—The central portion of the field is in Crawford County, with Robinson as the center, where there are three sands at 750 to 1 100 feet, although most of the production is obtained from about 950 feet. This has been an exceedingly rich district and has made many fortunes, as the field has a width of three to ten miles and it attained a daily output of 100 000 barrels by its third year.

Like the Casey district, the drilling can be done with portable rigs at a large saving over the use of derricks, and the contract prices of $1.25 to $1.50 that formerly prevailed have been reduced to the very reasonable rates of 70 to 80 cents per foot. The cost of a well complete and put to pumping ranges from $1 800. to $2 500.

Lawrence County District. — The southern portion of the field is in Lawrence County, with Bridgeport as its center, and while this is the deepest part of the field, it is by far the richest and has the best grades of oil. The belt is two to six miles wide and to date seven pay sands have been found that range from 800 to 1 950 feet in depth. The "McCloskey," or 1 950-foot sand that was discovered last year, is the deepest and richest thus far found, as it produces wells up to 3 000 barrels daily output. While the growth of this district has been slower, from the greater depth and expense of the wells, the output exceeds 60 000 barrels *per diem*, and the older wells are holding up remarkable well.

Drilling costs from $1.00 to $1.50 per foot, as caving ground requires more or less under-reaming. The cost of a well, complete, ranges from $2 500. to $3 500. in the shallower sands and from $4 000. to $7 000. in the deeper sands.

Market Conditions. — An 8-inch pipe line was built into the field in 1906, and there are now five pipe lines, or three 8-inch, one 12-inch and one 6-inch, with a combined daily capacity of about 110 000 barrels, that transport the oil to the large refining centers at Wood River, near St. Louis, 140 miles; at Whiting, Ind., 200 miles; and at the Atlantic seaboard, 900 miles.

About 900 steel tanks, of 35 000 barrels capacity, are scattered through the field that provide storage for about 30 000-000 barrels, and which have enabled the buyers to take care of the flush production without the usual slaughtering of prices.

The oil has sold throughout the flush production at 60 cents per barrel, excepting a small amount under 30 degrees B. that brings 52 cents. While this is a low price for such a high-grade refining oil, it is a much higher price than any other field ever enjoyed during the development or flush stage, when production always greatly outstrips the shipping facilities. Other fields have had to accept 3 to 25 cents per barrel during this early stage while awaiting the very costly pipe lines that are required to handle and economically transport a large production. As the pipe-line facilities are now able to take care of the output and are drawing on the surplus at the rate of 250 000 barrels per month, higher prices should soon rule, and recover not only the former price of 82 cents, but eventually reach $1.00 to $1.10 per barrel, which its paraffine base and excellent gravity warrant.

The oil ranges from 32 degrees to 39 degrees B. in gravity, excepting a small amount of shallow oil that is 28 degrees to 30 degrees B.

While ample gas occurs with the oil to operate the drills and

pumps and to furnish the adjoining towns, no very large quantities have been found thus far that are commensurate with its importance as an oil field. That larger and stronger gas wells will be found in the deeper sands that have not yet been prospected is quite probable, and gas lines from this field may yet supply St. Louis and Chicago.

Western Illinois.

In its early history, western Illinois was of considerably greater importance than eastern Illinois. For gas was found in commercial quantities at Litchfield in 1882, and lubricating oil was produced there for about twenty years; Sparta enjoyed gas for several years after its discovery in 1887, and since 1907 it has produced some excellent refining oil; while the Pike County gas field has supplied the local farmers since 1890.

Sandoval.—The modern or important production of western Illinois, however, is scarcely over a year old, and started from the accidental discovery of oil in a new coal shaft at Centralia, 60 miles east of St. Louis, in the autumn of 1908. Subsequent drilling developed a few small wells at a depth of 600 feet in the immediate neighborhood. In prospecting at Sandoval, $4\frac{1}{2}$ miles north, for the extension of this sand in 1909, it was found dry; but on continuing the drilling to 1 400 feet, a 40-barrel well (Fox No. 1) was brought in. On drilling (Fox No. 2) on the adjoining farm, the 1 400-foot or "Stein" sand was found dry; but on continuing the drilling, a 350-barrel gusher was struck at 1 525 feet in the "Benoist" sand that also yielded 5 000 000 cubic feet of gas daily. A dry season prevented much drilling that year, but last year a very rich oil pool was opened up that to-day is two miles long by a mile wide, on which are 40 wells that averaged an initial output of 118 barrels daily. This is the highest average yield of any pool in the state, according to the Illinois Geological Survey, and it is obtained from the base of the coal measures. The Stein or 1 400-foot sand is found to yield 40- to 60-barrel wells over much of the area, but at present this is cased off to go 150 feet deeper to the richer Benoist sand. Field pipe lines convey the oil to loading racks of the Indian Refining Company (independent) on the B. & O. R. R., or to that of the Ohio Oil Company (Standard) on the I. C. R. R. Last fall a 6-inch pipe line was built into the field so that the shipping facilities are now able to promptly take care of the output.

The grade of the oil is about the same as in Lawrence County

(gravity about 36 degrees B.) and sells for 60 cents per barrel at the wells.

Centralia.—The work of the Illinois Geological Survey shows that the Sandoval field is on an uplift that extends south to DuQuoin, and considerable prospecting is now going on along this promising zone, which passes through Centralia. Farther drilling into the deeper sands at Centralia brought in several wells recently in the Benoist sand; but as it is not so thick, they have not thus far proved as rich as at Sandoval.

Carlinville.—Drilling in the latter part of 1909 discovered gas at a depth of about 400 feet near Carlinville, 55 miles northeast of St. Louis, that is being used at that town for lighting and heating.

Bond County.—Drilling at Greenville, 50 miles east of St. Louis, in Bond County, in December, 1909, discovered a good gas sand at 950 feet. There are now several wells, yielding 1 000 000 to 2 000 000 cubic feet of gas daily, that supply Greenville (5 000) with gas for heating and lighting at 25 cents per 1 000 feet. This sand is at or near the base of the coal measures.

Drilling last autumn at Old Ripley, in the western part of Bond County, discovered an oil well at a depth of about 2 000 feet that is of very good grade, as it has a gravity of 39 degrees B. It has been difficult to get reliable information about this well, as the discovering company is absorbing all the leases in the neighborhood, but it seems to have a capacity of 25 to 50 barrels. Other wells are drilling in the neighborhood and the oil horizon seems to be in the Devonian horizon, or below the coal measures.

Livingstone. — In prospecting, two weeks ago, for a lower vein of coal with a diamond drill at Livingstone, 35 miles northeast of St. Louis, in Madison County, a strong flow of gas was struck in a thick sand at 581 feet. To the fact that the drillers were badly burned and the outfit set on fire was due the publication of this discovery. The gas is issuing with a roar from a 3-inch hole and the open pressure is at least 80 to 100 pounds; if closed in, it would probably show a rock pressure of over 200 pounds, but the fear of the gas getting into the mine has prevented its utilization, and it is allowed to blow off and burn as a huge torch that can be seen for miles at night. The attention of the oil men has not yet been directed to this accidental discovery, which is quite as important in pointing to an oil field as it proves the occurrence of a valuable gas sand, while the deeper sands are likely to be much richer.

Clinton County. — While this paper is being written, a paying oil well is reported near Carlyle, in Clinton County and directly south of Greenville. A little oil was found there last summer at about 1 000 feet, and if the above proves correct, it was probably an edge well and the pool has now been located.

Future of Western Illinois. — Since the writer discussed the general geology and developments of the Illinois oil fields before this society two years ago, western Illinois has made important strides forward towards the predictions then made. It is still in its infancy, however, and has barely started on the bright career that geological evidence so very strongly predicts — in fact, almost positively assures. Enough has been proved to demonstrate the oil and gas bearing value of the formations, but the production thus far is so moderate that oil leases are still very low and on a most attractive basis for investment. Whether St. Louis will grasp this golden opportunity to win the rich rewards that courage and foresight earn in new oil fields remains to be seen. She permitted the richest and most profitable oil field ever opened to be silently though promptly taken away from her in eastern Illinois by capitalists and oil operators from Ohio, Pennsylvania and Oklahoma. Will she again sleep on the opportunity of a lifetime in the oil field that is opening up at her doors?

Statistics.

The data in Table 1 are furnished by the Illinois Geological Survey and show the relative activity and importance of the principal producing counties of Illinois during 1910. The Marion County output represents the Sandoval pool, while the "miscellaneous" represents new or "wildcat" territory.

TABLE 1.

Wells Drilled in Illinois in 1910.

County.	Wells Completed.	New Production, Barrels.	Dry Holes.	Average Daily Yield, Barrels.	Field Opened.
Clark	112	1 802	31	22.1	1904
Cumberland	17	162	4	12.5	1905
Coles and Edgar	7	65	3	16.2	1905
Crawford	1 210	26 382	253	27.2	1906
Lawrence	679	61 015	95	104.5	1907
Marion	60	3 760	26	110.6	1909
Miscellaneous	54	70	48	11.7	
Totals	2 139	93 256	460	55.8	

Table 2 gives the output and value of the Illinois oil field since the Casey district began shipping in 1905. The 1910 production is the estimate of the Illinois Geological Survey, in which only the December output had not been reported as pipe line runs or tank car shipments.

TABLE 2.

PRODUCTION OF ILLINOIS PETROLEUM.

Year.	Barrels.	Value.
1905	181 084	$106 521
1906	4 397 050	2 982 120
1907	24 281 973	16 687 216
1908	33 685 106	20 211 063
1909	30 898 339	18 539 003
1910	35 000 000	21 000 000

Of *18 636* wells drilled to *January 1, 1911*, *only 2 847*, or *15.3 per cent., were dry*.

The relative position of Illinois in activity, production and percentage of dry holes, as compared with the other oil-producing states, is shown in Table 3, which gives the number of new wells completed during the month of January, 1911, the per-

TABLE 3.

PRODUCTION OF NEW OIL WELLS IN JANUARY, 1911.

State.	Wells Drilled.	Per Cent. Dry.	Average Yield per Well. Barrels.
New York	6	33	1.8
Pennsylvania	94	32	3.0
West Virginia	102	48	15.3
Ohio	134	25	13.5
Indiana	14	28	14.2
Kentucky and Tennessee	7	58	5.7
Illinois	*104*	*21*	*69.3*
Kansas	29	30	7.2
Oklahoma	292	10	89.8
Texas	6	67	2.0

Average daily yield of 4 436 California wells was 47 barrels in November, 1910.

centage that were dry, and the *average* yield per well. While these figures vary more or less from month to month, it gives an excellent comparison of the different fields and strongly emphasizes the fact that Illinois and Oklahoma are in a class by themselves as regards the magnitude of the *average well* and the small percentage of dry holes. Usually the average yield per well differs but little in these two states, but in January the Oklahoma yield was unduly increased by the bringing in of the very large wells in the new Osage Junction pool, while the per cent. of dry

holes was very low from the almost complete cessation of wild-catting, as drilling water could not be obtained on account of the drought. As the California data are not reported like the other states, the figures given are the best available.

Table 4 gives the relative importance of the principal oil-producing states at their zenith production, although Illinois, Oklahoma and California promise to exceed these figures as their development progresses.

TABLE 4.

MAXIMUM YEARLY OUTPUTS OF AMERICAN OIL FIELDS.

State.	Output.	Value.	Year.	Time Required to Reach Maximum.
Pennsylvania	31 330 021	$20 991 114	1891	32
West Virginia	16 176 757	21 879 064	1900	40
Ohio	23 941 109	14 769 888	1907	21
Indiana	11 339 124	12 235 674	1904	15
Texas	28 136 189	7 552 262	1905	16
Oklahoma	47 859 218	17 428 990	1909	18
California	54 433 010	30 675 267	1909	50
Illinois	*35 000 000*	*21 000 000*	*1910*	*6*

These states produce about 95 per cent. of the American output.

The great advance in the price of gasoline, from the actual shortage created by the remarkable growth of the automobile industry, stimulated an oil boom in London last year that resulted in unusual activity in all the foreign oil fields. Under vigorous development, the foreign fields increased their output, but the large increase in the production of Illinois, Oklahoma and California enabled the United States to more than hold its great predominance in the world's petroleum industry, as shown in Table 5.

TABLE 5.

WORLD'S PETROLEUM OUTPUT IN 1910.

Country.	Barrels.	Percentage.
United States	210 600 000	64.2
Russia	66 000 000	20.0
Galicia	15 000 000	4.5
Sumatra, Java and Borneo	11 000 000	3.3
Roumania	9 500 000	3.0
India	7 500 000	2.3
Mexico	4 000 000	1.2
Japan	2 000 000	0.6
Peru	1 400 000	0.4
Canada	400 000	0.1
All others	1 500 000	0.4
Total	327 900 000	100.0

The 35 000 000 barrels produced by Illinois in 1910 was one sixth of the output of the United States, although the youngest of the oil-producing states, and it was 10.7 per cent. of the world's production. If the output of Russia and Galicia is omitted, the Illinois production was about equal to the combined output of all the other foreign oil fields.

[NOTE. — Discussion of this paper is invited, to be received by Fred. Brooks, Secretary, 31 Milk Street, Boston, by April 1, 1912, for publication in a subsequent number of the JOURNAL.]

CHINA AND CHINESE ENGINEERING.

By W. D. B. Dodson.

[Read before the Oregon Society of Engineers, January 11, 1912.]

No more melancholy spectacle has ever been brought within range of my observation than China. That vast country and mighty people suggest to me, as nothing else ever has before, the broken column, — a work interrupted at its prime. A city buried in desert sands is lost forever, apparently by decree of the Supreme Power, and we view it as having fallen before the inevitable. Pompeii was blighted suddenly, with its activities at their height, but so complete and overwhelming was the disaster that sorrow over the ruin is without hope of returns. In China there was ruin, but not destruction; disaster, but not annihilation. What I saw there was not the work of the Power that fixes periods for races, but something superficial, human. China's blight was not natural, for beneath the waste of human energy and the seas of misery is still found the mold that shapes tremendous racial strength.

China is not senile and weak in all or even many powers that make for success. In all history, written or traditional, there is not such another example of racial tenacity as China reveals to the world. Traverse the globe over in every direction and nowhere else in human form will you discover the equal in grim, dogged, patient strength of China's teeming millions of coolie labor, which to-day stands ready to do the bidding of modern industry. Because of the glorious past, and because of the superb rudiments for achievement to-day, China's stagnation is profoundly pathetic to me, —.the most melancholy spectacle I have ever studied closely.

I take the liberty of hoping that the cloud is now rising, and that the New China, richer in opportunity than any other nation with the possible exception of our own, will soon come to its own. I cannot dissociate China's sudden decadence from the agency of her last conquest. That a nomadic and warlike tribe of people, few in numbers and strangers to the arts of peace, could take absolute mastery of the great China of three hundred years ago and work anything but ruin seems impossible. To my mind, China's progress has been the victim of war and

conquest. Manchu rule has been the domination of force, thinly veiled for years, yet effective in disrupting the necessary system of progress. I expect China to swing into the column of modern powers swiftly when the native merits of the people are unfettered.

That will be the New China. In this New China, no nation of the world except Japan can have a deeper interest than the United States. This interest is from the viewpoint of the military and naval strategist, and from the infinitely greater position of industrial neighbor. A robust, virile Cnina, and the American republic, would admirably balance on either side of the Pacific. Possessed of two of the broadest and richest regions of the world, trade between them must be in proportion.

China is essentially peaceful; in fact, has been too deeply so. She was the first of the great people to place the soldier in a despised class, the lowest in the social order. Manchu tribesmen sitting in China as conquerors are a convincing testimonial against adopting peace principles before the world is peaceful. Japan exalted the Samurai scholar-soldier above all other classes, and Japan overawes the Orient. China's Great Wall is the most eloquent protest of a peace-loving, peace-practicing nation against militant barbarism that has ever been discovered. It is that kind of a China, with a great, industrious, joyful people, more than contented with their homeland, which would be America's most desired neighbor across the Pacific, and certainly would be preferable to the rule of a peppery, war-loving and militarily exultant country, which we have viewed of late years in the ascendant.

China has brought from the past no effective engineering ability. In their day, there can be no doubt of preëminent capacity among the builders of the old China. It was a narrow, egotistic Occident that enumerated the Seven Wonders of the world, and omitted the work of the Chinese engineers of antiquity. Every one now knows of the Great Wall, which is found to-day extending from the sea out a distance of 1 500 miles, up mountain and down, in good condition, and there are remnants beyond, which disappear in the shifting sand dunes. The Grand Canal, an engineering audacity for the age of its construction, is an industrial marvel incomparably beyond any ancient achievement of the Occident. A system of highways was once constructed in China, radiating from Pekin, miles upon miles paved with broad flagstones, splendid grades established, rock cuts made around hills and even an occasional tunnel driven, and this system

comprising seven great trunks, connected every part of the empire with the capital. Out in Western China will be found to-day an occasional suspension bridge, with chain cables. One great Wu, sung for centuries in Chinese traditions, irrigated the Chengtu plain in the heart of Szechuan province, the home of 67 000 000 people, and any man who will go for days over the canals and ditches placed by the engineer of the hoary past must feel that the Occident has overlooked a leader among Nature's noblemen. Arches found at intervals over canals and streams suggest forgotten builders of note. China's Sorrow, the terrible Hwang Ho, or Yellow River, has matched itself against engineering ability of the greatest order, and often lost. A stream that can switch its debouch into the sea two or three hundred miles within as many years, and which is marked by the worst types of floods, is a worthy foe for any engineer the world has ever produced, occidental or oriental.

I hastily suggest these achievements to prove that China has had engineering ability. She will have again. But for all the years of modern times, while the Western world was forging ahead, the Chinese mind has been repressed. Whatever it was that worked the backset is seemingly passing away. Keenest interest is aroused in the minds of Chinese students over engineering problems. Those who have taken the American and European engineering courses have developed into enthusiastic and tireless workers upon returning home. Taotai Jeme was one of this number, and when I saw him last he was directing construction of the Pekin-Kalgan railway line, which led up through the formidable Nankau Pass. His work there was conceded of conspicuous merit, for he was driving the iron horse up the rocky course down which had poured in past ages hordes of Tartar tribesmen as they threw themselves upon the Chinese husbandmen. He is one of the new class now rising, which, with the aid of impartial Western engineering minds, will tap China's unmeasured latent resources.

In the period since Caucasians have come in contact with the Chinese, there has been no academic engineering instruction until within very recent times. The Great Examinations, the most impressive educational tests ever known in any land, were calculated to inspire knowledge of the literary classics only, and never suggested material sciences. The Chinese Civil Service, which stood upon the educational system culminating in the Great Examinations, and which made the ruling class below the Imperial Clan a strict literary democracy, had no place for the worker in material things.

For a few years, since Chinese leaders conceded the supremacy of Western science, students were sent to America and Europe, and later a polytechnic school was established in Shanghai, and certain phases of engineering were taught at some of the larger universities. Chinese graduates through the American and British polytechnic schools have made most progress. One Lee was chosen by Sheng Kung Pao as active manager of the Hanyang iron and steel plant, the Ping Hsiang collieries and the Tayeh iron mine. Jeme, already mentioned, went into railroad construction. Several younger in the field were rising in active work when I left China, three years ago.

These young men form the nucleus around which the vast army of engineers for the modern China will be gathered. Every industrial achievement of the West, and every science or art, will be welcomed. There is a universal demand in China for Western education. If finances permitted, the new political order soon to be established would find every man with average intellect eagerly absorbing Western knowledge. Everything in a modern state affecting the material world will have to be acquired. Transportation, on land and water, will be Western. The steamboat is displacing the stately junk at sea and on the river. The launch beats the junk and sampan on canal and small stream. The railway is often a pioneer for overland transportation for long distances, as there are large areas where wheeled vehicles have disappeared for many decades, except wheelbarrows. Electricity, chemistry, mechanics and even organization of aggressive business will have to be taught by the West.

China awaits it all eagerly. When the Great Examination system disappeared, in 1907, the old China surrendered. That was the real opening of the door. Given opportunity to put the political system in accord with these new aspirations, China will become a superb field for development, where the American engineer, working with and for the Chinese, will have the broadest opportunity for play of his constructive powers that can be found in all the world.

A brief survey of natural resources is opportune. These are as varied and abundant as we find on the American continent. China enjoys the range of climate, vast valleys and plains, mountain ranges and rivers, plentiful moisture and fertile soils boasted by the United States. Where uncounted centuries of cultivation have not been without due fertilization, soil yields are heavy. In the northern regions are the great loess areas, carrying that mysterious yellow, fine soil which is the most

persistently fertile of any ever cultivated. This is the soil which has a vertical cleavage, and is believed by eminent geologists to be a wind deposit rather than a water product. For a semi-arid climate, it is a marvel. An ingenious student has declared that the loess, which envelops all the northern area first inhabited by the "long black haired people" after their advent in China, has given the yellowish pigment coloring the skin of the Far Eastern Oriental.

The Great Plain, extending from Pekin and Tientsin southward to the Yangtze-kiang, a distance of about eight hundred miles, compares with the best section of the Mississippi basin plains. The Yangtze valley has more people than many empires, and is the most remarkable basin of all the world. Its agricultural yields are inconceivable, because authentic figures are not published. All the southeast coast country from the Yangtze abounds in fertile realms, and the West River valley in Kwangtung province is a small Yangtse. Manchuria, coveted by two great powers, has cereal lands of the utmost promise awaiting settlement and development. If Mongolia and Chinese Turkestan are not lost through Russian aggression, they have livestock and limited farming resources which could be made to serve an empire like that of China.

This broad latitude of country is not surpassed, if equaled, by the United States. Our fruits will thrive there. All that our farms produce, the Chinese can get from the soil there. Silk and tea, the two Chinese specialties, are incomparable, when the neglected and abused planter of that country is encouraged and protected. These two last crops can be made to yield annually possibly $80 000 000 to $100 000 000 each. American organization, stimulus to the producer, market methods and government encouragement would be a godsend for the teeming forces of China's rural communities.

Mineral resources are almost unbelievable. Much has been published upon hasty surveys and estimates, which is no doubt exaggerated. But the uncontrovertible evidence of production, with range of occurrence, favoring formations and superficial workings leave no doubt of China's immense stores of minerals.

Baron Richtofen, the famous German geologist, placed estimates upon the coal deposits that made the world sit up and take notice. He said that Hunan Province alone had an anthracite field equal to that of Pennsylvania. After spending a long time studying the formations of Shansi Province, he concluded that the cropping and slightly developed coal measures there

were without an equal anywhere. In the Western Hills, near Pekin, Pumpelly found coal mines which had been operated for perhaps two thousand years, where an extreme width of one seam was found to reach 30 ft. In Chili for a considerable distance about Chin Wang Tao, coal has been mined for ages, and there the big Chinese Engineering and Mining Company is now operating one of the great coal mines of the world, with expensive modern machinery. In Shantung an excellent soft coal has been mined by the natives for an unknown period, and there the Germans are developing several great coal mines on modern lines. In Manchuria the Japanese are making the Fushun collieries steady producers, with the avowed purpose of raising the yield to five thousand tons daily. In Kiangsi, Kiangsu, Honan, Szechuan, Hupe, Yunnan, Kwangtung and Kwangsi provinces good coal deposits have been worked.

Transportation for coal between mine and world market is exceptionally favorable. The Yangtze-kiang has a minimum low-water depth of 9 ft. to Hankow, 650 miles from Shanghai, and for nearly half the year is ascended by average coast and light ocean-going craft to that point. This transportation line intersects the great coal zone of China. For ages coal from Hunan has been taken by junk down the Siang River to the Yangtze, and thence conveyed on the Asiatic Father of Waters to the sea or consumers near seaboard. Before the steamboat came, solid strings of junks lined the Yangtze for hundreds of miles, one side passing upstream and the other scurrying down. As coal carriers, these were thought beyond any form of competition, and their records of per ton per mile charges went as low as 0.4 cent up and 0.2 down stream; but they are disappearing before the steam-driven craft.

Other rivers entering the Yangtze and the Grand Canal were the old coal distributing lines. The Grand Canal, built primarily for movement of tribute grain, or tax grain, from coast provinces to the capital, became a great coal highway. But coal mining had no hope until the railway came. Early travelers in China found coal not moving more than 100 li, or 30 miles, from the pit where mined, except by water. Railways are now connecting the important coal-producing centers. The Ping Hsiang colliery, the greatest developed by Chinese capital alone, has a costly 30-mile railway connecting it with the Siang River. Extensive railway work will within a few years open all. One firm offered to lay down for me good anthracite coal in an American Pacific port for $8 a ton, I taking the duty, they paying

steamship charges. Good coke, used in the iron reduction plant at Hanyang, and capable of similar use on this coast, could be brought here for a much lower figure than the prevailing prices of coke in the Northwest.

With her railway system better developed, with modern mechanical equipment for mine and bunker, and with an organized system for production and shipment, China could furnish the Pacific with its coal at far lower figures per heat unit than any fuel except California oil is now being provided here. There can be no question but what this fuel will soon be in the channels of trade; and in placing it there the modern engineer has a wonderful opportunity. Many informed men I met believe China can and will in due time duplicate the coal yield of the United States.

Iron occurrence is almost as general as coal. Hunan and Shansi were the scenes of ancient Chinese production, especially Shansi. In that province I inspected the old, old furnace type for reducing iron, and saw others for the Hunan product being used at and near Hankow. I made a special trip to the Tayeh iron mine, 80 miles below Hankow, and 15 miles from the Yangtze River bank. Here a great cropping of magnetic and hematitic ores was being mined, by the Hanyang Iron and Steel interests, for consumption in the Hanyang furnaces and for sale to the Japanese under a big loan contract. Terrace cuts were worked on the sidehill by coolie hand labor, ore was dumped on to mere platforms and discharged on to ore trains of a small railway that conveyed it to the river bank, where it was dumped on to the ground. Coolie labor drawn from the surrounding agricultural district was employed, at about 10 cents gold a day, and when work was suspended the coolies returned home. One coolie accounted for about one ton of ore a day between mine and railway, and the mining, transportation and handling charges to the hold of Japanese ships which moor at the bank for six months of the year were put at from 13 to 16 cents a ton gold. The Hanyang company manager told me it cost them less than one tael (then 63 cents gold) to mine and charge Tayeh ore in the furnaces at Hanyang, about 80 miles from the place where it originated. The 10-cent a ton mining record is certainly low, when you consider that hand labor performed all the mine work, and coolies shovel the ore from the cars, while others pick it up again in small baskets and convey it aboard the steamships. With steam shovels and modern loading equipment, all manned by Chinese cheap labor, the 5-cent mining costs per ton reported

from Mesabe Range could be lowered and the handling charges to ocean craft brought below any known record.

Development of China's iron ores has not even begun. Tayeh was really the only place where modern needs were being met while I was in China. Innumerable districts where Richtofen and other learned travelers through China found superficial workings of an extensive character are yet to be opened. At Tayeh the Japanese had made a loan of four to six million taels, and were taking pay in iron ore, at the rate of 150 000 to 200 000 tons a year at a phenomenally low figure. The Japanese were using this ore at the Imperial Steel plant at Wakamatsu, in Japan. A shrewd provision in the contract penalizing heavily where the iron content went below given percentages was working to Chinese loss, as the contract apparently had been based upon early shipments when magnetite was handled, and the main volume of shipments later was hematite.

The Hanyang Iron and Steel Company, since reorganized under another name, owned the Tayeh iron mine, the Pinghsiang collieries, and the iron furnaces and rolling mills at Hanyang. Sheng Kung Pao, recently minister of the Yuchuan Pu, or Department of Posts and Communications, and also, when I was in China, director-general of the China Merchants' Steam Navigation Company, was the moving spirit and principal owner in the sole big iron mining, reduction and manufacturing plant of China. Good progress was being made in producing commercial pig, railway rails and several rolling mill products.

Coke production was being attempted on a large scale at but two points, the Pinghsiang collieries, in the Yangtze basin, and the Tongshan mines, in Chili, the first being the work of the Hanyang company, and the latter of the Chinese Engineering and Mining Company. I brought samples of this coke to America, submitting them to the leading coast smelting works, and found one per cent. excess of sulphur the chief objection to their use here. As the coke I brought was from the upper vein or seam of the three mined at Pinghsiang, no doubt can be entertained that the lower seam would furnish a product meeting Pacific Coast requirements. After I made futile efforts to secure contracts for Chinese iron ore, pig iron and coke, the Western Steel Corporation, operating at Irondale, Wash., working through James A. Moore and Capt. Robert Dollar, closed a large contract with the Hanyang people. While this enterprise has struck obstacles, I am sure that the Pacific coast of America could build up a great metal manufacturing industry, using Chinese

raw materials, even after the Panama Canal cuts transportation charges on Atlantic seaboard products for this coast to one half or one third the present railway rates.

Copper was probably mined in Yunnan and Kweichau provinces of China before Romans ever thought of working the Rio Tinta copper mines of Spain. This metal was used for the very ancient Chinese cash mintage in periods antedating the Christian era. Recently a French syndicate, operating from Tonkin, or French China, has constructed a railway to the heart of the ancient copper zone of Yunnan, and there is prospect of important development work when the Chinese government permits modern operations. Copper abounds in many parts of China, two or three of the foreign concessions having been for such ores.

About one fifth of the tin of the world is mined in southern China, largely Yunnan Province. Crude mining methods, followed by cruder reduction and refining, gives the industry little opportunity to grow. Mercury has been packed out of Kweichau Province and shipped to the world for many centuries. Important cinnabar deposits are still found there, which are also promising of material development when properly opened. Antimony ores are being taken from Hunan Province to-day by the Germans, a concentrating plant being operated at Hankow to facilitate the trade. Manganese is being mined in connection with the iron industry. Szechuan has deep brine wells, from a few of which natural gas is procured to evaporate the brine. A salt marsh in the southern end of Shansi Province is reputed to have been used by the Chinese for five thousand years, being the salvation of the inland nation before it got a footing on the sea. Every mineral that we know is found there. Gold is barely mined at all, but this seems due to absence of proper encouragement, for there are many streams where panning methods are ancient custom. One quartz mill was erected in Shantung, by means of a foreign promotion, and dismally failed, for the mill preceded ore development. L. S. J. Hunt, the American, got a concession from the old Korean emperor and built up a great Oriental Consolidated Mining Company property, having 220 stamps, which is one of the large gold mining enterprises of the world. A Mongol prince's representative offered to take me on a fourteen-day journey north of Pekin, for examination of a placer deposit which he said was promising. Mineral formations are very favorable, the area of China immense, and there is no reason why it should not become a great gold-producing country in the coming years.

Foreign engineers direct all modern mining and reduction operations that I observed, but were training astute, observant Chinese staffs for the work. Germans directed the Pinghsiang collieries. Under Mr. Lee, a German staff was in charge of the Hanyang reduction plant and rolling mills. A German-American engineer was in charge of the Tayeh iron mine. The great plant of the Chinese Engineering and Mining Company had British and German engineers in charge, this being nearly entirely owned by British capital, following a struggle with the original Chinese interests. In Shantung, German capital and engineers direct all the modern coal operations of that district. No people of the world are giving foreign engineers a more cordial welcome than the Chinese.

Electric plants grow rapidly of late. Light and power plants were going up in the more prominent cities, the latest under Chinese ownership and management, with a foreign engineer in charge. No hydro-electric installations are practical, in the central or northern region, so all plants generate with coal fuel. As a rule the company getting the equipment contract has a contract about furnishing an engineer for a given period. Germans and British, with occasional Dutch and French, have most of this work in hand.

Railway construction in China has been fast for seven or eight years, and will be at a far swifter pace when the reorganized country permits industrial development to keep pace. The Imperial Railways of North China, a government enterprise, built by means of a British loan, covers the territory from Pekin to Mukden, via Tientsin and Chinwangtao. The main line mileage is about five hundred miles. A British engineer-in-chief directs the operating department, construction and maintenance included. Most of his staff are Chinese. A railway school is maintained to train mechanics and operatives. Chinese engineers, firemen, conductors and other members of the crew man all trains. Repair and new construction work is carried on in the large, well-appointed shops at Tongshan, where the Chinese make coaches and freight cars and will even reconstruct an engine. An official prominent in the company told me that the year preceding operating costs were but 28 per cent. of revenues, which astounding statement he maintained was based upon fair bookkeeping methods. Both freight charges and passenger fares are low, there being three classes of passengers.

The Pekin-Hankow line was built under a Belgian concession, with joint Belgian and French engineering, and all equip-

ment was drawn from those countries. The Shanghai-Nankin line was a British concession, where British engineers, materials and equipment were used exclusively. Americans were granted the Canton-Hankow concession, and opened work, but not being financed, hawked the franchise until Chinese wrath was aroused. The syndicate was trying to sell to a Belgian and French concern when the Chinese redeemed the grant and have prosecuted slow construction since by means of Chinese and British funds, with a proviso giving British engineering preference. In Manchuria everything in connection with the great South Manchuria Railways is Japanese, except the American rolling stock and rails, which were bought in this country, but these would have gone to Japanese factories had the country been able to provide them. A joint German and British concession was granted for the Tientsin-Pukow line of nearly seven hundred miles, German engineers and materials prevailing at the northern end, and British at the southern. In Shantung two hundred and fifty miles of main line railway has been built under German concession, everything being German in the work. At the time I left, the Chinese were building, with their own finances, engineers and workmen, the Pekin-Calgan line, and were making remarkable records in the charges for cutting and filling roadbeds, in some instances running about half the charges for same work on the Shanghai-Nankin line. The most insistent demand being made by the Chinese of foreigners at that time was for permission to have a freer hand in railway construction, with the privilege of purchasing materials and equipment in the market offering the best for the least money.

Many lines of industry beyond the possible scope of this paper were observed, wherein the foreign engineer and business manager were being given free rein. Cement manufacture and sugar refining are great industries, being conducted mostly under foreign guidance, and sometimes exclusive foreign control. Silk filiatures, flour mills, paper factories, cotton spinning plants and arsenals were being erected and operated under foreign guidance.

I have emphasized how engineering is largely determined. While I was at Shanghai, two railway advisers for viceroys of provinces were chosen. I made an effort to urge upon Chinese acceptance of young American engineers, arguing that our railway construction is greatest and hence we should have the best knowledge. A movement was started to name a railway engineer adviser for the imperial official controlling this depart-

ment, the minister of the Yuchuan Pu. I appealed to the representative of the United States Steel Corporation and other Americans to have our Asiatic diplomats use their influence in filling this position with an American, to give American equipment, materials and young engineers of this country a better chance in China. Most of the loans made there fix the nationality of the engineers, and the purchasing place for material and equipment. Nearly all engineers pull for the products of their own nations, even when not obligated to do so, and especially will they do this where prices are nearly the same and relative merits are subject of debate.

In enumerating a few resources of the country, I have omitted one of overshadowing moment, — China's reserve of labor. There is nothing approaching this elsewhere in the world. Chinese estimates of their own population give 410 000-000 to 420 000 000 people in the 18 provinces. Multitudes of the coolies are as fine specimens of physical strength as any race produces. Coolie bearers of the interior have been pronounecd by experts the third strongest class of the world, certain Chilean miners being placed first, and Turkish porters second. For feats of fortitude and prolonged endurance, these Chinese coolies have no superiors. Ways of life and traditional customs seem to limit range of initiative, but any man who has worked among them, and adapted himself to certain oriental principles, gains a very favorable impression of their future. I spent two years traveling over China with a demonstration telephone plant, of the Automatic type. After my expert mechanic furnished by the factory was taken ill and had to return home, I operated the plant with a Chinese crew without serious difficulty, and found their minds remarkably keen to master mechanical intricacies. Foreigners who have lived among them for years declare them marvelous mechanics. All the machinery going to the Orient is operated by the Chinese, with only loose supervision in most instances. For courage and daring, where a cool head and steady nerve are required, I believe the Chinese are in the foremost rank when given the proper discipline. I have seen Chinese coolie stretcher bearers in the Philippines go on to a field swept by a galling fire of the enemy and pick up wounded men with a nonchalant air that amazed some seasoned veterans of the American forces. In handling machinery which requires keen eyes and alert minds, they are ready to sail on the margin of danger to gain speed, and seem to enjoy the hazard involved. Certainly a race that can man the crazy junks which for cen-

turies have tempted the typhoon-whipped seas bordering China will become great navigators some day.

I found that amazing fund of labor willing, able, alert and inclined toward progress. Unless my chart of human nature is wholly in error, Chinese labor, properly directed in the midst of Chinese resources, will bring forth results to gladden the world. I can see nothing to prevent those people soon becoming a mighty nation of modern times, a neighbor of which the United States will be proud.

In closing I will presume upon your kindness by making a suggestion which has engaged my thought for some time. I believe that the engineer is the greatest business missionary that any country can send forth. America could advance her commercial interests in the Orient in no more effective manner than by encouraging the employment there of young American engineers, instructing the Chinese in our own engineering schools, and by putting as many Americans as may be possible in the technical schools of China to aid in educating the masses who must soon reach out for this information.

Our country has been debating trade extension. Our diplomatic service has been taken from its altitudinous position of abstract political studies. Commercial representatives are being sent to the Orient in growing numbers. But the merchant offering an American product to a business dominated by a European engineer makes little headway and sells nothing except where patent superiority exists. But a great Chinese enterprise, guided by an American engineer, will not wait for the advent of the American merchant. Plans and specifications will be made to fit the American product, and orders will cross the seas without the merchant's help.

China must have abounding engineering help in the regeneration which seems to be at hand. America has hundreds of able, eager young engineers who would revel in the opportunity to work out the great problems that must be mastered in bringing China to her proper industrial level. If the heavy exporting interests would combine in some plan of this kind, and even put a man in the field to seek opportunities for American engineers, they would find the trade growing out of the departure the most gratifying investment they ever made.

The suggestion I make is that the Oregon Society take the initiative in such an effort. If engineers of the country joined, the great factories and exporting merchants would probably respond. Railway construction will be rapid in the coming

years. Power plants, big factories, wharves and docks, oil tanks, telephone and telegraph systems, vehicle highways, canals, deeper harbors, drydocks, arsenals, reclamation canals and dikes, and a multitude of other improvements, will be in order. For the generation or more during which China will be laboring in the transition from the old to the new, foreign aid in all this work will be welcomed. America above all other nations should extend it. A great, prosperous, stable China means more to us than to any other power.

[NOTE. — Discussion of this paper is invited, to be received by Fred. Brooks, Secretary, 31 Milk Street, Boston, by April 1, 1912, for publication in a subsequent number of the JOURNAL.]

DISCUSSION OF PAPER, "ECONOMICAL DESIGN OF REINFORCED CONCRETE BEAMS."

(VOLUME XLVII, PAGE 203, DECEMBER, 1911.)

PROF. JOHN P. BROOKS. — At first glance the diagrams in Figs. 2, 3, 4 and 5 are startling, as they convey the impression that four per cent. of steel reinforcement is approximately as economical as is one per cent. A further study of the figures, however, shows that the advantage of using percentages higher than usual is small, particularly in beams of moderate span and of normal ratios of breadth to depth. Fig. 5 represents the variation in cost of a beam 12 in. deep and 20 ft. span with various percentages of steel. For any except the lightest loads this is an uneconomical design, whether the beam be of steel, concrete, wood or any other material, simply because the breadth becomes greater than the depth and the section is not a proper one.

A beam 20 ft. long will usually be required to carry a floor system at least 4 ft. wide and not less than 200 lb. per linear foot beside its own weight, and the bending moment will be, in lb. in.,

$$M = \tfrac{1}{8}(200 + w')20^2 \times 12,$$
$$= 120\,000 + 7\,500b,$$

if the entire depth of the beam be 12 in. and w' be the weight of the beam per linear foot. Solving by ordinary methods, with .01 and .02 as values of p, b is found to be 24.5 and 16.5 in. respectively. With prices of concrete at 30 cents per cu. ft., and of steel at 3 cents per lb., the cost of these beams will be $17.63 and $15.50 respectively. The saving of $2.13 by using two per cent. of steel is reduced somewhat by the fact that the span between beams is increased 8 in. in the assumed 48 in. between centers, and the floor must be correspondingly strengthened. If the slabs be not continuous there might be also some saving in their length as well as in their depth. There should also be deducted the additional cost of bending and placing three extra $\frac{7}{8}$-in. rods. These details, however, do not affect the general conclusions of the article.

If, instead of a rectangular section, a T-beam be used with a 4-in. flange and one per cent. of reinforcement, the cost will be $13.50. Here five $\frac{3}{4}$-in. rods and a web 10 in. wide were used.

In many kinds of construction the cost of forms for a T-beam is more than for rectangular section, but, as the cost of placing the steel is less, it seems certain that the T-beam with one per cent. is cheaper than a rectangular section with two per cent. of reinforcement.

It is a common saying that the best reinforcement is more cement. The strength of concrete varies very nearly as the ratio of cement to the whole volume of concrete. So, if a 1 : 2 : 4 concrete has a safe strength of 600 lb. per sq. in., a 1 : 2 : 3 mixture might safely carry 700 lb. per sq. in. Using this value and one per cent. of steel the width becomes 17.2 in. and the cost is \$13.10, with cement at \$2.50 per bbl. and aggregate at \$1 per cu. yd. This beam might possibly be further reinforced to some advantage.

It may be of interest to state that, if the weight of the beam be considered as a part of the constant dead load, the economical width is given very nearly by

$$r = 0.8\sqrt{nq},$$

in which r is $f_s \div f_c$ in the author's formula (4), page 204, and q is the ratio of cost of steel to that of concrete. Then p becomes about one per cent., which is not very far from the proper value when the width is, as usual, considerably less than the depth.

For example, let the depth of the above beam be 16 in. With one per cent. of steel the cost is \$9.77, while with two per cent. the cost is \$9.35, a difference in favor of the greater reinforcement that may be neglected if the extra cost of erection be considered.

The general problem of economy of design of beams is very complex and the author is to be complimented for emphasizing one particular phase.

OBITUARIES.

Benjamin Douglas — A Memorial.

MEMBER OF THE DETROIT ENGINEERING SOCIETY.

ON November 19, 1911, a message from Brazil brought the sad news of an accident resulting in the death of Benjamin Douglas, a prominent charter member and former president of the Detroit Engineering Society.

Benjamin Douglas was born in Detroit, December 10, 1859. His father, Judge S. T. Douglas, was one of Michigan's best-known jurists; his mother, Elizabeth Campbell Douglas, was a woman of rare intellectual power. In 1860 the family moved to Grosse Ile, where Judge Douglas had purchased a farm and built a beautiful home. As a boy Mr. Douglas attended the public school and also had the advantage of the home teaching of his gifted mother, with which preparation he entered the University of Michigan in 1878.

After finishing his university studies in 1882, he was employed as assistant engineer by the Detroit Bridge and Iron Works, where he remained until 1885, when he received the appointment of bridge engineer of the Michigan Central Railroad Company, a position which he filled for twenty years.

In 1890 Mr. Douglas married Margaretta Porter Biddle, who with five children survives him. The following year his love for the home of his boyhood and youth induced him to return to Grosse Ile, which continued to be his home until his death.

When the Detroit River Tunnel was projected, Mr. Douglas was appointed tunnel engineer. In 1910, the tunnel having been finished, he opened an office in Detroit as a consulting and contracting engineer.

After finishing some construction work in connection with the railroad grade separation in Detroit, he went to Brazil in April of last year, having been retained by the Sorocabana Railway Company to inspect bridges and supervise such changes as the increasing traffic demanded. His field work in Brazil was nearly completed and his plans were made for an early return to his home and family when he fell about sixty feet from a new bridge he was inspecting. He never recovered consciousness, dying in a few hours, while on a special train which was taking him to the nearest hospital.

Benjamin Douglas achieved high standing among bridge

engineers of the United States and Canada; he was noted for the successful ways in which he solved the problems incident to rebuilding railroad bridges without interfering with traffic. Some of the important work done by Mr. Douglas while with the Michigan Central was the rebuilding of the Grand River bridge, Niles bridge, Kettle Creek trestle and cantilever bridge, Niagara Falls, and replacing of truss bridges. Strengthening of the Niagara River bridge was, perhaps, the most important work undertaken by him for the Michigan Central, as it called for the highest engineering ability and ingenuity. The new bridge over the St. Joe River was moved and placed as a body about thirteen feet on a skew without delay to passenger trains.

In 1891, twenty years ago, the old Grand River bridge was replaced by the new bridge without interfering with traffic. The moving out of the old spans and the connecting of rails on the new spans was done on the last two sections of one hundred and fifty-four feet each in twenty-six minutes. This was one of the first bridges, if not the first, to be handled in this way, and is, so far as known, a record unbeaten to this date.

In 1894 he designed the first bridge with a solid I-beam ballast floor, a construction far superior to any other solid floor construction, excepting only the modern concrete floor construction.

To him is due in a very large measure the success attending the building of the Detroit River Tunnel, and during the development of alternate schemes, he devised a novel method for the building of subaqueous tunnels on which he obtained patents.

Benjamin Douglas was a man of unusual intellectual power, which was to some extent concealed by his habitual reticence and his innate modesty. Aside from his engineering achievements, the enduring monuments of his useful service, his life found expression in his intense love of his family and of his home; he loved the fields, the woods and the river; he knew the trees and the wayside flowers; the birds were his friends; his farm and garden were his playgrounds; a man of few words, slow to censure; a trusted friend whose loss will be keenly felt in the community where he lived and in the wide circle of his professional friends.

WARREN S. BLAUVELT,
Chairman of Committee.
J. D. SANDERS,
Member of Committee.
J. C. MOCK,
Member of Committee.

George Corbett Dunne.

ASSOCIATE OF BOSTON SOCIETY CIVIL ENGINEERS.

MR. GEORGE CORBETT DUNNE died suddenly of heart disease at his home in Newton, on the evening of May 23, 1911.

Mr. Dunne, who for many years had been Boston manager for the Portland Stone Ware Company, was born in Bathhurst, N. B., November 9, 1849, and came to Boston when a youth of eighteen years. In early manhood he became associated with the company of which he was so long the manager. His industry, zeal and business talent won him rapid promotion, and contributed in large measure to the striking growth of his company's business during the past forty years.

Though of a retiring disposition, Mr. Dunne made and retained a very large number of devoted friends, not only in business life, but in religious and fraternal circles. He was especially interested in church work, and was for about thirty years a member of the Eliot Church of Newton. He was one of the organizers of the Newton Young Men's Christian Association, and was always deeply interested in its welfare. He was also a member of several Masonic bodies, including Dalhousic Lodge, A. F. and A. M., of Newton; the Royal Arch Chapter and Gethsemanic Commandery. He was a member of the Boston Chamber of Commerce, of the Massachusetts Highway Association and of the Newton Republican Club.

Well known to the civil engineers of Boston through his interest in their work, and through the relation of their interests to the industry which he represented, he was ever ready to adapt the products of his company to the ideas and suggestions of the profession. Always public spirited and aggressive in the advancement of every good cause, and holding to the highest standards of business honor, Mr. Dunne will long be missed by those who were privileged to know him.

Mr. Dunne was married, on January 24, 1883, to Miss Katherine Henderson, who, with three children, Winslow, Olive and Pauline, survives him.

B. R. FELTON,
F. W. CLARK,
F. A. BARBOUR,
Committee.

Association of Engineering Societies.

Organized 1881.

Vol. XLVIII. MARCH, 1912. No. 3.

THE SANITATION OF CONTRACTORS' CAMPS AND THE PATROL OF WATERSHEDS.

SANITATION OF CONTRACTORS' CAMPS, NEW YORK CITY WATER SUPPLY.

By A. J. Provost, Jr.*

[Read before the Sanitary Section of the Boston Society of Civil Engineers, December 6, 1911.]

The sanitary work undertaken by the Board of Water Supply in connection with the construction of the Catskill Aqueduct, and the constructions relating thereto for furnishing the city of New York with an additional supply of five hundred and fifty million gallons per day, has included regulating and controlling the mode of living and the sanitary conduct of the large number of laborers employed on the work, together with their medical supervision and the effective disposal of all waste products.

The line of work occupies approximately one hundred miles of territory, some of which is sparsely settled. In numerous places it crosses the watersheds of important supplies, including the Croton watershed, which furnishes the present supply to New York City. The territory occupied was unable to furnish more than a very small percentage of the men to be employed, and the introduction of many thousands of alien laborers, in view of the conditions to be met, appeared to demand the es-

*Sanitary Expert, Board of Water Supply, New York City.

tablishment and maintenance of sanitary precautions not heretofore employed on similar work. It was considered essential that the communities through which the work passed should be protected so far as possible against the introduction of contagious and communicable diseases; that the various watersheds should be safeguarded in every reasonable manner against contamination; and finally, in order that the work might proceed orderly and effectively, it was considered desirable that the health of the labor force should be maintained in the highest degree consistent with reasonable precautions.

The work is believed to be particularly interesting on account of the close association which has existed in the methods adopted for general sanitation and preventive medicine. The work comprised under these two heads is in some respects so closely allied that no sharply dividing line exists between them. In this instance, however, all of the work performed under both of these subjects has been under a central control, in which respect it is believed to differ from previous attempts of this nature.

The principles of preventive medicine as applied have aimed at securing pure supplies of water and food, the protecting of foods against injurious influences, the vaccination of the force, the isolation of established and suspected cases of contagious or communicable diseases, laboratory research and expert diagnoses.

The principles of sanitation as applied have aimed at effecting reasonable cleanliness and the absence of local nuisance and unsanitary conditions. The administration of such work is much more complicated than the mere formulation of rules and regulations. Responsibility for administration must be assumed in such cases either by the state, the municipality or by the contractor. In the present instance, general rules and regulations were incorporated in the specifications, and each construction contract covered the basic requirements. The administration of these was placed upon the contractor through the services of an approved physician supervised by the engineer and his sanitary experts. It is the contractor's duty, for instance, to provide and maintain suitable buildings for the housing and needs of his workmen and their families, to provide sufficient supplies of water of proper sanitary quality, to construct and maintain approved methods of wastes collection and disposal, to discharge employees violating the sanitary ordinances, to cause the physical examination and vaccination of all applicants for employment, to provide medicines, surgical and medical treatment for his employees, to present weekly reports of the population,

surgical and medical cases, deaths, vaccinations and sanitary condition of the camp, works, etc.

TABLES SHOWING MORTALITY AND MORBIDITY FROM TYPHOID FEVER.

Jacksonville, Florida. June-Oct. 1898 ⊛
2nd Div. of the 7th Army Corps.

Regiments.	Mean Strength	Cases of Typhoid Fever.		Deaths from Typhoid Fever.	Deaths from All Diseases
		Certain.	Certain and Probable		
Second Illinois,	1,095	253	341	18	22
First North Carolina,	1,164	147	227	16	20
Second New Jersey.	1,155	185	318	29	32
First Wisconsin,	1,232	209	311	46	48
Fiftieth Iowa.	1,097	164	253	33	33
Ninth Illinois,	1,288	153	248	18	28
Second Virginia,	1,220	105	152	17	20
Fourth Virginia.	1,274	135	231	21	28
Forty-Ninth Iowa,	1,236	378	612	50	50
Total,	10,759	1,729	2,693	248	281

⊛ Camp organized about June 1, occupied until Oct. Some regiments leaving in Sept.

San Antonio, Texas Mar. 10 - July 10-1911
Maneuver Div. U.S. Army.

Organization.	Mean Strength June.	Cases of Typhoid. certain and Probable	Deaths from Typhoid Fever.	Deaths from All Diseases.
Eleventh Infantry,	924	–	–	–
Fifteenth Infantry,	969	–	–	2
Eighteenth Infantry,	1,022	–	–	–
Thirteenth Infantry,	929	–	–	–
Twenty-second Infantry,	1,033	–	–	–
Tenth Infantry,	1,016	–	–	1
Seventeenth Infantry,	954	–	–	–
Twenty-eighth Infantry,	951	–	–	–
Third Field Artillery,	847	–	–	2
Fourth Field Artillery,	741	–	–	1
Engineer Battalion,	536	–	–	1
Signal Corps,	197	–	–	–
Ninth Cavalry,	744	–	–	–
Eleventh Cavalry,	1,143	–	–	3
Sanitary Troops,	795	1	–	1
Total.	12,801 ⊛	1	–	11

⊛ about 25% immunized.

In a general way it may be stated that, under those contracts where the burden of responsibility and expense has been most fully accepted and most willingly carried out, the laborers have been most permanent in their connection with the work, and have been of a generally higher standard of intelligence and efficiency, and that the contractors themselves have been most satisfied with the results. These conditions represent the economic and practical side of the question.

In regard to its vital side it may be said that experience of all times has shown that where attempt is made to maintain in one spot more than a very limited number of persons or animals there is danger of their extinction by poisons resulting from their waste products. The modern city, with its elaborate systems of water supply, sewerage and waste collection and removal, has finally reduced this danger to a minimum, but until very recently temporary encampments — whether for purposes of war, exposition or the construction of important industries and public works — have frequently been visited with serious epidemics and deplorable loss of life from diseases which we now regard as preventable and unnecessary.

The general practice of suppressing information in such cases has prevented even a partial understanding of these matters, and it was not until the publication of investigations made subsequent to our war with Spain that the serious and criminal side of the matter was realized by the people generally. These reports show that more than 90 per cent. of the volunteer regiments developed typhoid within eight weeks after going into camp; that about one fifth of all the soldiers of the national encampments had typhoid fever, and that the mortality from this disease amounted to 86¼ per cent. of all fatalities.

These results have been tabulated and appear in Plate No. 1, in comparison with the results obtained at a similar encampment established by the United States Government at San Antonio in 1911, where approximately the same number of men were encamped for about the same length of time. No comparative result could more strikingly show the tremendous advance made in applied sanitation since 1898. A somewhat similar comparison exists in the records of military morbidity from preventable diseases in the Japanese army during their campaigns against China and Russia. The remarkable results in both cases cited is conceded to be due to the observance of sanitary precautions heretofore neglected.

Light has recently been thrown on the subject of typhoid

outbreaks by the discovery of the fact that certain persons having had typhoid carry in their bodies for many years after recovery the active typhoid bacillus. One of the most remarkable instances of this kind was quite recently observed in connection with a localized epidemic of typhoid in the city of New York. All of the 54 cases were confined to consumers of milk coming from a dairy in a neighboring state. Examination of the dairy showed no probable cause of infection, and none of those handling the milk had been typhoid patients except one man who had had the disease forty-six years before. Samples of his stools were examined and found to contain the bacillus of typhoid in large numbers. Except for cases of such origin, and imported cases from infected districts, it would be possible to substantially rid many of our cities from typhoid. Given the presence of one typhoid carrier in an encampment, and the ordinary privy pit for him to use, the flies may be depended upon to carry the disease to and infect all the other inmates who are not for some reason or other immune thereto.

Therefore, when we study the methods of sanitation practiced by our army in the Spanish War, by operators of many mining camps, by the directors of numerous state, national and international expositions, etc., the statistics of infection are less surprising than the apparent number of immunes, both in the infected districts and among those communities to which convalescents from the disease return. Prior to 1907 it had become axiomatic that troops of the United States army could not be maintained in a field encampment longer than three weeks without the appearance of typhoid. Now, on account of the general adoption of complete incineration of human discharges and the sterilization of drinking water, they can be maintained indefinitely anywhere with substantial immunity. This result has been fully confirmed in the labor camps of the Catskill Aqueduct now being maintained under sanitary regulations in charge of the speaker and his associate, Dr. H. D. Pease.

The principal encampments for the Catskill Aqueduct work are located at Brown's Station, near the site of Olive Bridge dam, where houses are provided for about 4 000 men, women and children, and at Valhalla near the site of the Kensico Dam, occupied at present by about 1 000 people, but which will hereafter be considerably enlarged. Along the 90 miles of aqueduct between the Olive Bridge dam and the northerly limit of New York City are employed about 15 000 men, most of whom are housed in about 75 other regulated labor camps. Seven of these

camps, housing about 1 500 persons, are located in the Croton watershed, and other laborers are housed within the sheds of other public and private supplies. Every reasonable attempt has been made to secure healthful conditions in the camps and to prevent contamination of these water supplies.

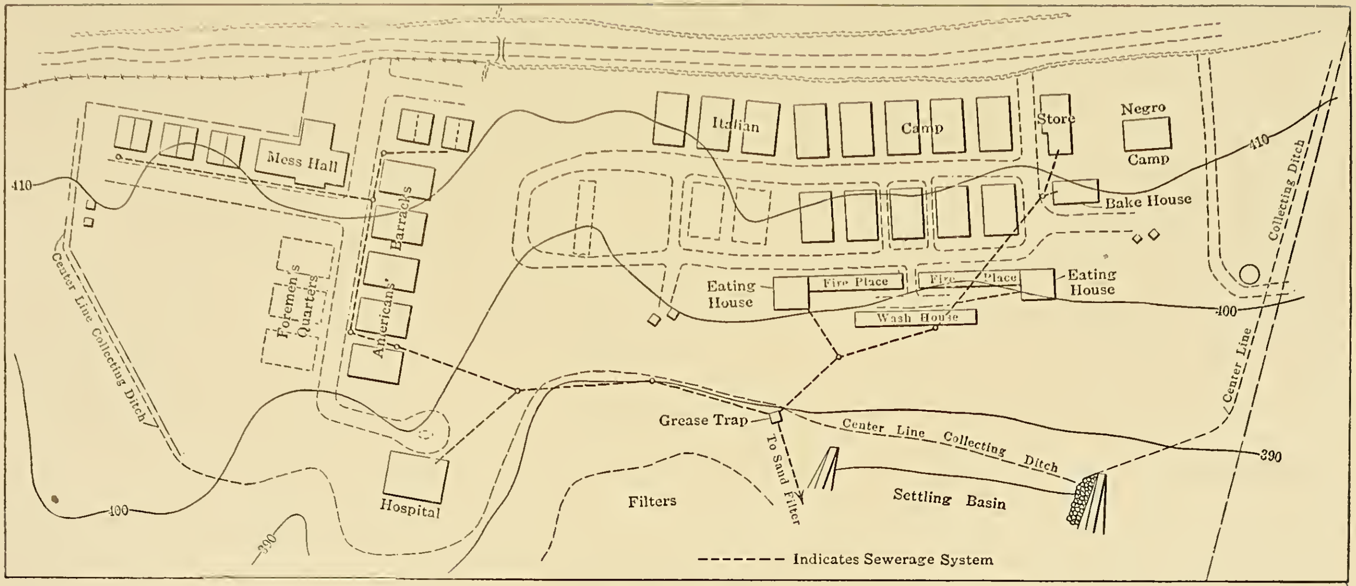
The general procedure in the Croton shed has been as follows:

Land for camp sites is usually leased or purchased by the contractors after official examination and approval. A careful topographical survey of the site is then made and mapped by the engineer, upon which the contractor designates the location of his proposed buildings, the source of water supply, the distribution piping, sewer lines, etc. This design is kept as compact as is consistent with proper air and light, for the reason that the area is enclosed with a manproof fence, and all rain water falling within same is collected, filtered and sterilized.

The sanitary works consist of one or more incinerator units, according to the size of the camp, for the combustion of human wastes; one garbage incinerator; drains for the collection of all kitchen, laundry and bath wastes; a grease trap for the reception of these liquid wastes before filtration and sterilization; diverting ditches to exclude rain water falling outside of camp area; collection ditches to deliver to a common point all rain water falling inside of camp area; settling basin with capacity for twenty-four hours run-off from camp area; sand filters, two or more units, to receive and filter all camp rain water after passing through settling basin; a chlorinating apparatus for sterilizing filtered camp wash and waste water before discharge into streams tributary to the New York City supply.

During working hours away from camp the men are supplied with and obliged to use galvanized iron receptacles. These are returned to camp daily and their contents burned in the incinerators provided for this purpose.

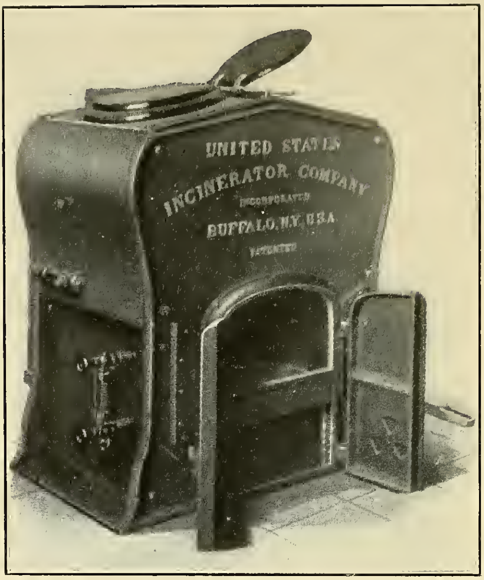
All camp buildings are erected from approved plans. These include sleeping quarters, mess halls and kitchens, wash houses and laundries, hospital and dispensary, isolation hospital, incinerator toilets, stables, etc. Sleeping quarters are provided with 400 cu. ft. air capacity, $2\frac{1}{2}$ sq. ft. window area, $\frac{1}{3}$ sq. ft. vent openings for each inmate. All windows, doors and vent openings are screened. Not more than eight men are allowed to occupy any room, and the usual procedure is two men per room. The preferred type of bed is a canvas stretcher laced to an iron pipe frame without mattress or springs.

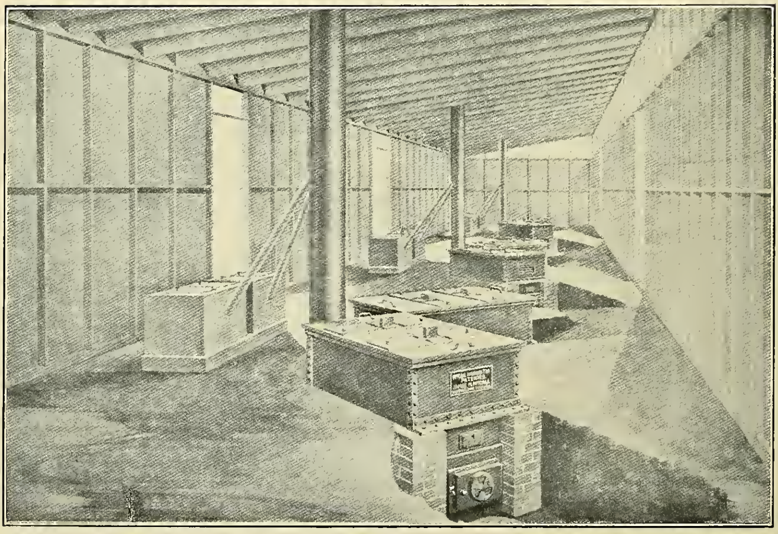


CAMP BLAKESLEY.

General View of Camp Bradley.

Filters at Croton Lake, Contract 24.





INCINERATORS.

The storage, preparation and eating of food in sleeping quarters is not allowed. There is usually a recreation room in each barracks, well heated, and the entire building is frequently lighted by electric lights. The mess halls and kitchens are required to be of proper size, well ventilated and thoroughly screened. Wash houses and laundries have cement floors, shower baths, lavatory accommodations and laundry tubs.

The hospital contains a doctor's office and dispensary with complete inventory of drugs, and equipped with first aid to the injured; an operating room with table, full equipment of instruments and adequate lighting facilities; a ward room with beds for 2 per cent. of force, allowing 600 cu. ft. for each bed; a detention room of about 1 200 cu. ft. capacity. There are also provided sleeping quarters for nurses and orderlies, bath room, storage for linen, cots, bedding, etc. The isolation hospital is a small building remotely located for the reception and treatment of cases of contagious diseases. It is surrounded by a man-proof fence and equipped so that patients treated therein may be completely isolated until regularly discharged.

The incinerator houses are as a rule modeled after the United States army type, containing either the McCall or United States Evaporative furnaces, with seating capacity based upon one seat for about every twenty persons using same. The process in these types is slow and frequently accompanied by somewhat objectionable odors. The apparatus being portable, it is too light for severe use under unskillful management, entailing burdensome charges for renewals and repairs. To overcome these disadvantages numerous modifications have been tried, the most promising of which appears to be the type suggested by L. E. Brink, and as operated by the Keystone Construction Company near Mt. Vernon. This consists essentially of a rectangular building with concrete floor throughout, well lighted, ventilated and screened; the four corners of which are partitioned off to form four separate toilet rooms with three or four seats each. They are provided with removable iron receptacles, the contents of which are transferred to a grate-bar furnace occupying the central portion of the building. This type of furnace and building bids fair to replace in labor camps of some size the army type, which is made purposely light, for transportation, and is, consequently, short lived.

The stables are, as a rule, well-constructed buildings of ample size, having concrete or non-absorbent floors. All manure is collected and removed daily from the vicinity of the camps. Other buildings usually present are a commissary for storing and

sale of food products and a bakery where most excellent bread is as a rule prepared.

Water Supplies. — The water supply of each camp must be provided from an approved source, and is frequently examined. Many hundreds of different supplies have been tested in the course of the work, and these examinations have fully confirmed the original rulings that open wells, unprotected springs and surface waters are undesirable. In some places springs and open wells have been enclosed and protected from surface wash, and in two or three instances filtered surface water is used, but, generally speaking, the most satisfactory supplies are furnished by deep wells properly cased. The taking of water by dipping is prohibited, and all tanks and reservoirs for the storage of water for domestic purposes are required to be covered.

Food Supplies. — Examination and control of food products has as a rule been restricted to regulating the purchase of raw milk from approved dairies, and to the screening of foods to be consumed in a raw state or without cooking subsequent to their purchase. The restriction of food peddling has been in some cases required.

Each labor camp is in charge of an approved physician employed by the contractor. Applicants for employment are physically examined, and open cases of tuberculosis are rejected. If accepted, the applicant is vaccinated, unless he can produce a recent certificate of vaccination from one of the other camp physicians. Vaccine and diphtheria antitoxin are furnished in desired quantities by the New York City Department of Health without charge, in order to provide uniform and fresh products.

Weekly health reports in prescribed form are prepared by the camp physicians, giving the census of white and black, male, female and infant population; the number of medical and surgical cases, presence and nature of any contagious or infectious disease, number and nature of deaths, vaccinations performed, general sanitary condition of camps and works, etc. In addition, the physician is required to at once report by telephone or telegraph, using prescribed code, all suspicious cases of contagious or infectious disease as soon as his suspicions are aroused. The tentative diagnosis is at once confirmed or corrected by means of laboratory examinations of blood, sputum or excreta, as the case may be. This procedure admits the establishment of the most prompt regulation and control and largely eliminates the undesirable excitement and hysteria which so frequently are associated with unconfirmed diagnosis.

The foregoing attempts to state as concisely as possible the general features of hygienic regulations which have been formulated and largely carried out.

The conditions to be met are entirely alike at no two camps, and, in like manner, no one camp is at all times equally well administered. Constant cleanliness of the living quarters is one of the most difficult matters connected with the problem. The tendency of the inmates is persistently toward the condition of filth natural to them. Sanitary squads where provided by the contractors are of varying efficiency, and the camp which to-day may be properly designated as "Spotless Town" will, perhaps, two weeks hence require re-baptism in more senses than one. Constant effort appears to be the price of cleanliness.

The work has, naturally, attracted the attention of many people. Some there are undoubtedly — like the sociologists, for instance — who in their zeal would like to accomplish the ideal at once. Others there are, like some of the contractors, who think too much is attempted. But in between there are many who have approved the work and expressed their satisfaction with the results. To those on whom the responsibility rests it has been gratifying to observe the substantial absence of typhoid throughout the entire work, and to them in view of this result all that has been done appears worth while. It may be safely said that in the future no large public work will be undertaken without greater attention to sanitary care of labor than has usually heretofore been the custom.

WACHUSETT RESERVOIR, METROPOLITAN SUPPLY OF BOSTON.

By Wm. W. Locke.

The construction camps of contractors on the Wachusett Reservoir were located beyond the stripping lines or off the watershed when it was practicable to do so; and when such a location would place the camp too far away from the work, it was placed on the unstripped surface; in either case on high land or gravelly knolls where deep holes were dug for wash water and privies, which were treated with chloride of lime and covered with earth when the camps were abandoned, unless they were upon the area to be stripped, in which case the contents were excavated and carried off the watershed, care being taken to remove all gravel and sand which showed any signs of being contaminated.

The camps were kept away from streams or ravines, and water was supplied to them either by pipe lines or wells.

A practicing physician was employed by the board to keep close watch of the health of employees, and all cases of contagious disease were removed at once to hospitals off the watershed. The total number of typhoid fever cases which developed in the camps or among the employees for the eight years while construction work was in progress was twelve, a remarkably small number in comparison with the thousands of men who were employed during that time upon the work.

While soil stripping was in progress, light, movable privies were carried along just ahead of the stripping gangs and located on the unstripped surface, so that the men could have no excuse for going anywhere else, and the foremen were given strict orders to see that they did *not* go anywhere else. In this way the excreta was removed off the watershed with the soil. This also meant a great saving of time to the contractors.

Patrol of Watersheds.

Undoubtedly most of you are well acquainted with the sources of the Metropolitan water supply. For the moment please recall to mind the fact that it is made up of two large natural reservoirs and a series of seven artificial reservoirs, with the ponds and streams draining into them. The first reservoir, Lake Cochituate, is about 18 miles, and the last one, Wachusett Reservoir, about 40 miles, from Boston, all being connected by aqueduct or open channel with one another and with the two large distributing reservoirs at Chestnut Hill and Spot Pond.

Connected with the chief engineer's office in Boston is a biological laboratory. The biologists collect and examine weekly, biweekly or monthly samples of water from the reservoirs as well as from taps at several points in the Metropolitan District. The chief engineer is thus able to furnish the best water in the system at all times to consumers, or, if any unusual conditions arise, like the typhoid epidemic in Cochituate village last year, or unusual growths of organisms causing objectionable tastes or odors develop at any point, that particular source of supply can quickly be cut out and not used again until conditions improve.

The water is generally held in storage for long periods of time in these open reservoirs, where it is subjected to the action of light and air and then must run for considerable distances before arriving at the point of consumption; so that the prob-

ability of any disease germs passing through the reservoirs or surviving the long journey, should any happen to get into the feeders, is extremely remote.

Many of the large swamps upon the watersheds have been effectively drained by carefully constructed ditches with board bottoms, and intercepting ditches have been dug along their edges to intercept the upland waters and carry them around the swamps. These ditches are kept clean and in repair by a maintenance force in the employ of the Board.

On the Cochituate and Sudbury watersheds the large villages of Natick, South Framingham and Westborough and the city of Marlborough have sewerage systems, the drainage from which is carried outside the watersheds and disposed of upon filter-beds, and the surface drainage from the thickly populated portions of Natick, Marlborough and Sterling is filtered before being admitted to the supply, as well as the sewage from several isolated institutions and dwellings.

The area of the Cochituate watershed is 18.73 sq. miles, with a population of 14 518 in 1910, of which only 4 877 resided in dwellings not connected with sewers, or 260.4 per sq. mile.

The area of the Sudbury watershed is 75.2 sq. miles, with a population of 22 111, 9 756 of which were in unsewered houses, or 129.7 per sq. mile.

The area of the Wachusett watershed is 118.19 sq. miles, with a population of 5 282, or 44.7 per sq. mile.

The duty of the sanitary inspector is to see that polluted drainage is disposed of in such a manner as not to affect the water supply; to be on hand when changes are being made *in* drainage so as to give proper advice, and, when contagious diseases which may affect the water supply are reported, to see to it that proper precautions are taken.

The soils on the watersheds are in general gravelly, which makes the problems of sewage disposal much simpler than they might be with clayey soils, and allows the application of definite rules and regulations which do not need to be modified except in rare instances. These rules and regulations were drawn by the State Board of Health and adopted by the Metropolitan Water and Sewerage Board, and in brief are as follows:

No polluting matter of any kind shall be put directly into the water supply. No cesspool, privy or other place for the reception, deposit or storage of human excrement or for house slops, sink wastes, water which has been used for cooking, or other polluted water, shall be located within 250 ft. of the high-water

mark of any lake, pond, reservoir or stream unless such cesspool, privy or other receptacle is so constructed that no portion of its contents can escape into the water. No garbage, manure or putrescible matter whatsoever shall be put into the water supply or upon the ground within 250 ft. except in the cultivation and use of the soil in the ordinary methods of agriculture.

No stable, pigsty, henhouse, barn yard, hog yard, hitching or standing place for horses, cattle or other animals shall be located or maintained within 250 ft. unless suitable provision is made to prevent any manure or other polluting matter from being washed into the water.

The location of hospitals, tanneries, currying shops and slaughter houses must be approved by the State Board of Health, and they cannot be maintained upon the watershed unless they comply with all the provisions required by the State Board of Health for the purification or disposal of sewage, drainage, or other polluting or organic matter which may be discharged therefrom.

No person shall bathe in the water supply.

Addressed postal cards are furnished to the clerks of the local boards of health, upon which they report promptly to the sanitary inspector all cases of typhoid, cholera morbus or dysentery occurring in their towns. These cases are then immediately investigated by him and such precautions taken as are necessary to insure the safety of the water supply.

MORRIS DAM, WATERBURY, CONN.

By H. G. Payrow.

Mr. Provost's description of the location of camps on the New York Water Supply calls to mind the experience of camp locations in the construction of the Morris Dam that is now being built at Waterbury, Conn. The camps were at first located off the watershed area, but subsequently it was found to be advisable to relocate them directly on the watershed, where they could be placed under strict sanitary regulations.

When the construction began in 1909, the camps for the laborers were located outside the watershed, in part on private land leased by the contractor. It was thought, by locating the camps here, no special attention would have to be given to sanitation, but in a short time conditions became neglected and filth was common, so that within a few months from the beginning several cases of typhoid fever had developed, and it became

necessary to take radical steps. The sick laborers were removed to hospitals, mattresses and bedding burned, the camps cleaned and fumigated, and all other laborers who had been using these camps were discharged. Furthermore, in order to avoid a recurrence and to establish better sanitary conditions, new camps were located, not off the watershed, but directly on it. By this means, camps came on city property and could receive careful and rigid supervision.

A small area has been fenced in with five strands of barbed wire and only one entrance provided, and all around the area a 3-ft. trench has been excavated, and this trench drains into a sump from which water is allowed to percolate through the ground. Water which the men use for washing clothes, dishes, and so on is taken care of by a small sand filter, located conveniently, and into which they are required to empty all receptacles that have been used for washing. Refuse and excrement is deposited in large galvanized ash cans that are provided in the outhouses and on the works. These cans are taken each day to a farm that is located outside of the watershed area. Here the cans are emptied, washed, sprinkled with lime, and afterwards returned. Daily inspection is made of the camp and all outhouses about the works. During the past two years that the camps have been located on the watershed area these careful methods have been adhered to and no serious sickness has been developed. With a few exceptions, laborers and other employees have readily complied with the established rules and regulations for sanitation.

[NOTE. — Further discussion of this paper is invited, to be received by Fred. Brooks, Secretary, 31 Milk Street, Boston, by May 1, 1912, for publication in a subsequent number of the JOURNAL.]

THE WORK, AIM AND CONDUCT OF THE ENGINEER.

By Charles T. Main, Member of the Boston Society of Civil Engineers.

[Presented to the Society, March 20, 1912.]

I cannot be accused of doing much preaching, but on this occasion, when the President may choose his own subject, there is nothing to prevent him from choosing a text from which to preach. The text may be old, but sometimes it is well to turn over the barrel and preach an old sermon which the old members may have forgotten and which is as good as new for the younger members. Instead, therefore, of reading a paper on some engineering topic, I desire to express a few thoughts which may not be new, but which by repetition are kept in mind.

The Standing of the Engineer.

The engineer by reason of training and on account of his work is usually of a retiring disposition. His training usually has not been such as to make him a good speaker, and his work is such that he will not hastily express opinions. As soon as one problem is solved he is busy on another, and then as some one else will do the talking, he does not get the credit for the work which he has done. In spite of this trait, which is a good one to some extent, the importance of his work and the method of careful and systematic study of various problems, are not only being more widely recognized than formerly, but it is also recognized that his training fits him for positions of greater responsibility and broader scope. And so it has been said many times recently that the engineer is beginning to come into his own. Engineering is now classed among the learned professions, and with this elevation of the profession come greater responsibilities and greater necessity for maintaining the conduct of the same on a higher level professionally and ethically.

This is an era of great industrial development, and the work of inventing, developing and putting into actual operation of the scientific and industrial enterprises must fall largely upon the engineer. In the annual message of the President of the American Society of Mechanical Engineers, Colonel Meier says, "Engineering is the profession of the present, and will dominate the future."

On account of the commercialism prevalent to-day, it is with greater difficulty that the high standards are maintained. In this development the engineer is coming to be relied upon more, so that his position is becoming increasingly one of responsibility even as to leadership. With this increasing responsibility must come a keener realization of the professional and ethical sides, in order to insure further increase of the regard in which the profession is held.

With the elevation of the profession and recognition of its work, there comes an opportunity for better financial returns.

Financial Returns.

A fellow engineer said one day, "The hardest thing which I have to do is to make out a bill for services." It is here again that the natural modesty of the man is such that he is unable to appreciate the worth of his own services.

Some of us are called upon to make investigations and reports on enterprises involving the expenditure of millions of dollars, and the conclusion reached and the signature at the end of the report may prevent our clients from losing large amounts, or may cause them to embark in an enterprise which will net them great profits.

The concentrated knowledge and experience of years may be given in a short period, and yet we are apt to measure the value of our services on a per-diem basis, which will amount to a pitiable sum compared with the importance of the service rendered. This condition should be remedied so that the returns will be commensurate with the value of the services rendered. A lawyer of high standing in making his charges would consider not only the time required but the importance of the case or value of services rendered.

There is no good reason, aside from custom, why the engineer should not be as well recompensed for his services as is the doctor or the lawyer. The engineer engaged in the industrial development furnishes his services, as a rule, to a clientele that can afford to pay the full value for services rendered. Where a problem has been carefully studied, and the work carried out in accordance with the final conclusions, the result enables a saving in cost of production or an increase in profits. The engineer who works along these lines is carrying on the work of efficiency of which so much has been said and written recently. The industries can well afford to pay the cost of obtaining the benefits derived from good engineering.

In the regular pursuit of design and construction, there seems to be no way of charging more than some definite fixed sum or percentage, the aggregate of which cannot be large unless the undertaking is unusually large.

Many of our profession hold salaried offices, and the salaries are not very large as a rule; but the tendency of later years has been to make a better return for services rendered.

To the younger members the progress seems to be slow, but with ability and willingness to work there is no reason why success should not follow. Some of the greatest engineers have been men who have not had the advantages of technical training and have forged their way to the front by close application and native ability.

The young graduate from a technical school is apt to think that he knows it all; but if he is well balanced he will soon find that he has laid a good and substantial foundation during his studies on which to build his education for effective work which will be of value to his employer, and which will develop from day to day in the actual performance of his work. If he is well grounded in the fundamental principles of the profession he will be able to undertake and carry out any work which is assigned to him; but he should have patience and not expect too rapid advancement in position and salary.

For these reasons the younger men should be modest in their expectations and consider a part of their remuneration the valuable experience which they are acquiring.

After an engineer has had many years of experience and hard work, and his work and judgment are of great value to his clients, he should rise above his modesty and charge a sum commensurate with the value of his services. At the present time, however, it does not seem as if a large percentage of the profession could derive much more than a good living from strictly professional work.

Some time ago one of my clients who is very successful in manufacturing said that his son thought he would like to be an engineer, and the father desired some advice as to the best thing for a boy to do. I told him that if he wanted the boy to make a lot of money, he should take him into business with him, but if he wanted him to have an honorable profession which would probably procure a living for him, but not much margin, to make an engineer of him.

Some time ago there appeared in the engineering papers a schedule of charges for professional services of consulting engi-

neers, as prepared by a number of representative engineers of St. Louis and endorsed by the Engineers' Club of St. Louis.

This may be of some service as a guide for charges, and is printed as Appendix A.

Character of Services Rendered.

Money should not be the chief consideration in this life. It is a good thing to have, but it is an illusive thing and easily parted with, and the chief pleasure comes in doing something well.

Regardless of the compensation received, it should be the aim of the engineer to render the very best service possible, and the aim of such service should be to produce a maximum return for every dollar expended. This does not mean that a design shall be necessarily a cheap one in the ordinary sense of the word, for sometimes the very best results obtained are from the very best construction, all things considered. Sometimes when permanency is not an object, a more temporary, cheaper and less efficient design is the most economical to adopt.

A common definition of an engineer is "One who deals with the forces of nature and adapts them to the uses of mankind." A prominent man gave a more modern definition as "A man who can with one dollar do what any fool could do with two." A combination of these might give a fair idea of what is expected of the present-day engineer.

It is the exercise of judgment based on experience which will determine what, considering all things, is the most economical design to make.

All work should be based on facts and not on theories or suppositions, and if based on scientific laws with proper use of the same, the results will be satisfactory. Nothing should be taken for granted, and the work or statements of others should be carefully checked before being adopted.

There should be intelligence used in the amount of work and expense put into preliminary studies and plans. They must be accurate in substance, but do not require to be worked out in detail at a waste of time and expense. This is a common failing among the younger men that prevents them from obtaining quickly and inexpensively information for preliminary studies which are liable to be discarded, and it is in such work that details are apt to obscure the main result.

The success of a man will depend upon his ability to produce results in an expeditious manner which shall be accurate, in which good judgment shall be used so that the finished product shall

be adapted to the use to which it is to be put and shall have been accomplished at a reasonable expenditure.

He should also be able to understand men and to know them, to meet his superiors properly and to carry out their wishes and instructions. He should also be able to tell his subordinates what is wanted and, if necessary, how to get it.

Reports should be made clear and concise, and accompanied, where possible, with definite recommendations; and no statements should be made which cannot be proven. They should be tactfully written so as to eliminate unnecessary opposition, but upheld with firmness of purpose.

The true success of a man is not to be measured by the accumulation of money, but the success of accomplishment of work which adds something to the general good for mankind and the advancement of the profession. There are many engineers engaged in enterprises who will be more gratified in obtaining successful results than in the financial returns to themselves, which, although important, is a secondary consideration.

Consultation with Other Engineers.

In these days an engineer who is doing a business of any considerable extent must necessarily cover a broad field of activities. If I may be allowed to be personal for a minute, this may be illustrated in our own work, which may be designated in a general way as the design and construction of industrial plants. This term covers a very broad field, but let us consider only one special line, that of textile manufacturing. The object of any planning of this sort is the production of textile goods of a desired quality and at the minimum cost, and all the various details of organization of machinery, construction of buildings, arrangement of power plants, etc., have this in view.

The field that is covered by this work is extremely broad, covering some branches of civil engineering in connection with the site, surveys, railway or dock facilities, water supply, sewerage disposal, foundations and heavy masonry structures. It may include hydraulic engineering if the power is derived wholly or in part by water. Mechanical engineering enters into the design of the steam power plants and the distribution of power, in the oganization of the machinery and sometimes in the design of special machinery. In these days of electric power and transmission and lighting, electrical engineering enters into the solution of some of the problems. To cover and protect the machinery buildings are required, in the design and construction of

which some knowledge of architecture is necessary; and to make a harmonious plant adapted to the production of some particular product, some knowledge must be had in advance, or acquired at the time, of the process of manufacture.

It is almost impossible in one short lifetime for a man to acquire intimate knowledge of all these different branches of engineering, and the man should be broad enough to acknowledge this fact and should employ, if the business is large enough to warrant it, men who are skilled in these different branches, or to consult with other engineers who are specialists in the various branches, and it is gratifying to see that this is becoming common practice, and that engineers are recognizing the benefit of such coöperative work and the interdependence of the profession as a whole.

If the business is large enough, this can be done by the constant employment of specialists who may not all the time be employed on their speciality, but are constantly available, all working in harmony under one responsible head. If the business is not large enough to warrant the constant employment of such men, the services of outside engineers can be obtained from time to time and paid for as used.

The growing custom of consultation of engineers on the same work emphasizes still more the necessity for a definite code of ethics in order to aid them in maintaining a proper attitude to the various interests involved.

Ethics of the Profession.

Some of the professions have had for many years a code of ethics which should govern the conduct of the members of that profession. The advisability of the adoption of some code by the engineering profession has been discussed, but as yet no code has been officially formulated.

The American Bar Association adopted a code of professional ethics in 1908, and the Bar Association of the City of Boston adopted a code in 1909, portions of which are given in Appendix B.

The Massachusetts Medical Society has adopted a code of ethics, a copy of which is given in Appendix C.

It would be proper for the Boston Society of Civil Engineers, which is the oldest engineering society in the country, to adopt a code, and for the sake of presenting something definite for discussion, if nothing more, I have formulated a short code which is based upon that of the Medical Society and is given in Appendix D.

If there is no written code, it is our duty to keep in mind certain fundamental principles of brotherhood, which should in general be a guide to the conduct of our business and of one engineer to another, some of which are as follows:

One engineer should never attempt to secure work from a concern who is already employing an engineer doing similar work. If the owner or client desires to make a change, that is his privilege, and there can be no wrong done if another engineer comes in on invitation; but to deliberately attempt to secure work which would naturally go to the other man is beneath the dignity of an engineer.

Criticism of another's work should always be done in a kindly spirit, and the good points mentioned in addition to those which are not good. Owners or managers often decide as to whether the engineer's advice and plans shall be carried out, and take the liberty of changing the same. There is oftentimes more than one way to do a piece of work, and each way may give equally good results, and we should, therefore, hesitate before condemning another man's work, especially without a full knowledge of all the conditions. Of course there are sometimes cases where something is radically wrong, and we should then not hesitate to say so, if called upon to report on the same.

The success of any one member is beneficial to the standing of the whole profession. The failure or rumor of failure of one throws more or less discredit upon the whole.

The solicitation of business should be done with the least possible show of commercialism. An engineer cannot advertise his brain as a storekeeper can his goods. It is, however, well for a man to keep his name in some proper way before the people who are likely to need his services. This can be done in a way which is effective by publishing short descriptions of work, accompanied with pictures and plans of the same, in a manner instructive and interesting.

Advertising in the commercial sense apparently does not bring much business into an engineering office. An effective manner to advertise is to prepare papers on subjects connected with one's line of work, which will be read by those who may have such work to be done. There is then a distinct suggestion to the minds of men that the author knows something of what he is writing about.

The solicitation or offer by salesmen or manufacturing concerns to do the engineering work connected with the application and installation of any apparatus which they may have to

sell, and of contractors for buildings to furnish plans for the same, is to be deplored. The owner thinks he is getting his engineering for nothing. As a matter of fact, he is not, but is paying well for it, as very little work is done gratuitously. Furthermore, the problem is not studied in all its bearings and the results are liable to be unsatisfactory as a whole, and will probably cost more in the end than if a fair sum were paid for carefully studied plans of the whole plant.

The treatment of superiors should be courteous and with little criticism, as it may be impossible for a subordinate to know all of the conditions entering into the solution of a problem, a portion of which, only, he is acquainted with. A subordinate should always be free to express his opinion to his superior, if he thinks he sees any way to improve the work in hand. A subordinate should always endeavor to sustain his superior unless he is aware of a false position on the part of the superior.

The attitude of a superior to a subordinate should be that of helpfulness and encouragement, and as much responsibility should be put upon the subordinate as he can carry. Kindly criticism will accomplish more than abuse, and as a rule this will not be abused.

The acceptance of "rebates," "commissions" or "rake-offs" by the engineer, from manufacturers or parties furnishing apparatus, cannot be too strongly condemned. To the engineer doing an honest business, these offers of commissions are very disagreeable, and as a rule are equally so to the parties offering them, although they do not intend to assume any loss from this practice, and in some instances it may be legitimate business. It is liable to place the engineer following such practice in a very embarrassing position and quite likely to destroy his business. The engineer should in no way compromise himself so that he will be unable to accept, reject or give an unbiased opinion of any apparatus based upon its merits.

Some business houses consider it legitimate business to offer special prices through engineers' offices as legitimate sales discount, where the engineer undertakes to act as the agent for the purchase of materials or apparatus, which discounts perhaps the client could not get. In such a case there is a proper relationship existing between the engineer and his client. There is a difference between a legitimate discount offered in the due course of trade for the benefit of the client, and an attempt at coercion on the part of a vender to avoid honest competition.

When proposals are received which offer a bonus to the

engineer, he should return the same, asking for a revised price omitting such bonus, or refusing to do business with the concern if he feels that the concern is not doing a legitimate business.

If a special discount is given as a charge against salesmanship, which is saved to the vender by not having to drum up trade, and which the purchaser cannot obtain under the rules of the vender's business if he purchased direct, it is the duty of the engineer to discuss such offers with his client and, if agreeable to him, to take advantage of such special discounts and to give the client the advantage of the same.

In every case the compensation of the engineer should be fully covered by the amount paid him by his client, and the client should receive the benefit of any reduced prices which the engineer may obtain for him.

Willingness to Share the Benefit of Experience and Knowledge.

An engineer of experience possessing information which is not of a private nature which is of benefit to the profession in general is broad enough to publish such information for the benefit of his brother engineers. He will find that, looking at the matter even from a selfish point of view, he will not be the loser, for it will bring the man into greater prominence and call attention to the fact that he probably knows as much or more of this particular subject, and that, therefore, he is the man to be employed or consulted in work involving this particular subject.

The men of experience and standing in the profession should always be glad to impart to the younger men any information which they can. They should never stand in the way of the younger man improving his position, even if it is at a sacrifice to their own interests. If the younger man has an opportunity of obtaining a better position elsewhere, it should either be met with equal consideration of some sort or he should be allowed to change his position.

The younger men, on the other hand, should be governed by a feeling of loyalty to their employers and the profession which should deter them from taking undue advantage of circumstances which for the time being might temporarily enhance the value of their services.

The relations of an engineer and his assistants should at all times be governed by a spirit of fair play on both sides.

Preparation of Papers.

One way of performing service to the profession is the preparation of papers on subjects with which a man is more familiar than his brother engineers. This is a duty to the profession and to the societies of which he is a member, and as mentioned before, this is not only of benefit to his fellows but also to himself, in keeping him before the people whose attention he is desirous of reaching.

The preparation of papers designed solely for the purpose of advertising should not be encouraged, for such papers are usually of very little or no value to the profession and not to the credit of the author.

A paper should be carefully written and should treat the subject in such a manner as to add to the information on the subject. An engineering paper should be definite in its statements, and extreme care should be taken to have the statements accurate. There should also be no exhibition of partisanship.

Most papers on engineering subjects which are only general in their statements do not add much to the valuable knowledge on that subject, and papers which are written carelessly and with inaccurate statements are not only of no value but may be harmful.

Expert Work and Testimony.

The engineer is called upon oftentimes to prepare reports on values of properties and damages to properties by public takings or improvements. In working up these reports, he should take great care to study the problem from all viewpoints and should assume a judicial attitude towards the claims of the parties at interest. It is quite easy to set up a theory of damages and, assuming such a theory to be correct, to make figures which are favorable to the interests for which he is working, and this is proper, provided he believes the theory to be correct and to meet the conditions fairly. He should at all times properly work in the interest of his client, but he should also keep in mind the rights of the opposing party.

It is natural that there should be a difference of honest opinion regarding values, but it does seem sometimes that this difference is so great as to cause one to believe that there is no real method which could be adopted to determine the true value; and that the opposing engineers were so hopelessly at variance as to throw discredit on the profession.

It would be far better and the results obtained would be

more logical and nearer some true basis of reasoning if engineers could be employed on both sides of a controversy to get together and thresh out the values on some plan to be agreed upon, than for them to work on theories diametrically opposed and to testify to courts or commissioners who very likely know nothing except the law and must come to some decision from the contradictory evidence introduced.

There should be an agreement on all the facts of the case as far as possible, and it should be the aim to work out a settlement of the case, if possible, without the necessity of going to court, thus saving time and expensive litigation and deferring the payment of just damages to some remote date.

It is along these lines that good work can be done in conservation of labor, time and money.

Working up reports for the settlement of cases is interesting and may be profitable work, but court work is very apt to be unpleasant and oftentimes seriously interferes with the regular work, as it is necessary to be prepared for fixed dates and to be in court at inconvenient times.

It is not an uncommon thing now for engineers to be appointed as adjusters in claims of contractors or owners or in claims for damages or to determine the values of properties. In all of these cases they should attack the problem with an open mind and endeavor to see clearly the viewpoint of all the interested parties and the effect of certain actions on values and to reach a conclusion which will be just.

Relation to Contractors.

Reliable contractors are honest and intend to live up to the plans and specifications. No contractor should be expected to give any more than is called for by the plans and specifications. Some contractors estimate low in the expectation of being able to get by with something inferior to what is called for. All men are human, and most men are careless, and for these reasons it is essential to have as much inspection on a job as is necessary to see that the intent of the plans and specifications is carried out.

This work of inspection and of interpretation of plans and specifications should be done with the exercise of a good deal of judgment, with a mind open to the interests of both the ownes and contractor, with clearness and firmness. In many casrs where claims are made by the contractors it is due to the fact that they are not familiar with the plans and specifications. In

many cases, however, there may be a conflict or a chance of more than one interpretation to be put on them. In the decision of all of these questions the engineer should assume a judicial attitude and render his decision with fairness to all parties interested. His decision may not be satisfactory to either party, but it must be clear in his own mind that he has done the right thing to all.

No one can see more clearly than he all sides of these questions and reach a proper decision. Sometimes that decision may not reflect any credit upon his own work, but it should be met fearlessly, if the fault lies in the preparation of the plans and specifications.

Care should be exercised in the preparation of specifications so that they will describe the class of work and grade of materials which are intended and expected, with clearness and conciseness. A better class of work should not be called for than is required for a particular purpose, nor should it be called for with the idea that something inferior will be obtained, which will pass. Just what is desired should be called for in the specifications and demanded by the inspector on the work.

The attitude of the inspector, or better the resident engineer, should be one of assistance rather than of criticism. He should assist the contractor in the study of the requirements and see that the contractor does not start wrong and then have to be corrected. This latter attitude is one tending to cause delays, misunderstandings and bad feeling and is a source of unnecessary expense to the contractor and owner, for delay means added expense to him, and tends to render less effective the whole organization.

Public Work and Politics.

Nearly all of the problems of a municipality and a great many of the state and nation are engineering in their nature, and there are no men who are better trained and qualified to deal with these questions than the engineer.

There are a great many of our profession employed regularly in work for the municipalities, states and nation, who are doing good work. There are a great many who are not in such regular employment by the governments, who could be of great assistance, if they were willing to give some of their time and effort for the public good. Engineers should hold many of the important offices for which their training should peculiarly fit them. It is considered by many a thankless task, but it is the duty of

every man who is better qualified than his neighbors to take his turn in the administration of public affairs and to do his share of the work.

There is no need of a man becoming a politician in order to serve his town or city on some of the many boards required for the transactions of the public work, and there is no need of considering such service as a thankless task; for the man has the satisfaction of knowing that he has done something of value to the common cause, even if his work and motives are sometimes misrepresented.

If a man is willing to serve the public he should endeavor so far as he is concerned to do his work to his own satisfaction, without fear or favor, and if he is desirous of remaining in office he will find that this is the best kind of politics.

From personal experience covering many years of service on various boards I have found that the engineering member is the one who is called upon finally to formulate the opinions and write the reports, and with his instinctive method of seeking for the truth and of using logical reasoning, it is probable that the final results will be much better than if the conclusions were reached and report drawn up without his assistance.

The inherent modesty of the engineer is here illustrated in his reluctance to appear to be seeking public office and to be obliged, if he accepts, to explain and perhaps defend his actions in public meetings.

Individually, as a mass, or as a society, we have been and are reluctant to give any expression of opinion or to indorse any public movement or enterprise, and it is time that we were more progressive in this line.

A man who does things, or a body of men who push things, will sometimes make a mistake. The one who does not make a mistake occasionally is the one who is too conservative to do anything and one who makes the most grievous mistake of all, doing nothing. Of the two the former is preferable. It is perhaps by our mistakes that we learn the most.

It is time that this society, which is a strong one, should make itself felt to a much greater degree in public enterprises, in the forming of public opinion and in the various phases of our government.

The Chief Requisites for Success.

The road to success in any business or profession is not an easy one. This is particularly true with reference to the pro-

fession of engineering, and it appears to me that the chief requisites are about as follows:

Some natural bent or liking for the work and a good stock of imagination. This may be inherited or acquired.

Close application in the work of preparation in the school, office or field, without many outside attractions.

Industriousness for many years after the first years of preparation. It sometimes seems that the application is too close, but it is difficult to make a success without close application and it is a rare person who can give much time to play and yet succeed in business. Occasional let up or change of work is necessary, but for the greatest success it seems that we must work most of the time during the working years and later give up practically all of the detail to the younger men, reserving only the direction of policies, consultation work and general guidance of the business.

Knowledge of the fundamental principles of engineering which underlie all practice. This should be the aim of the scientific schools rather than an attempt to cover too much detail. The latter can be acquired after the school years. The great majority of graduates of the scientific schools get into some line of work which is different from what they had expected to, and it is for this reason that a man should be well grounded on fundamental principles, so that he may undertake with some intelligence any work which is put up to him.

Integrity in work and business and fairness and justice to all. In the long run, a reputation for integrity in all his dealings, rather than brilliancy in attainments, will do more than anything else for promoting the business of a capable engineer.

Some business knowledge. This is the thing which is usually lacking in the young graduate. More time spent on business law, preparation of specifications and contracts and some in common letter writing would be of great benefit.

The engineering courses in technical schools are, as a rule, not broad enough in this respect. They do not tend to make a young man a broad thinker nor a good mixer. If a man can afford the time and money, a combination of the college and technical school should be of great advantage to him.

And, last of all, but perhaps the most important, is good judgment, called, oftentimes, "horse-sense," in the application of fundamental principles of engineering and everyday life.

APPENDIX "A."

SCHEDULE OF CHARGES FOR PROFESSIONAL SERVICES OF CONSULTING ENGINEERS, AS PREPARED BY A NUMBER OF REPRESENTATIVE ST. LOUIS ENGINEERS AND ENDORSED BY THE ENGINEERS' CLUB OF ST. LOUIS, MO.

1. For preliminary study and report upon a project or examination of a project prepared by another engineer and report on same:

(*a*) Charges, $50 to $100 per day for the first two to ten days and $25 to $50 per day thereafter, plus all expenses, including salaries paid assistants, with an allowance of 25 per cent. of such salaries for general office expenses.

(*b*) In lieu of the above, at the option of the engineer, a percentage charge varying from 1 to 2½ per cent.

2. For preliminary study, report and final detail drawings and specifications:

Charges same as under paragraph 1, (*a*), or, at the option of the engineer, a charge of 3½ per cent.

3. For preliminary study and report, preparing detail drawings and specifications, awarding contracts and acting in a general supervisory capacity during construction, including office consultation, but not including continuous supervision, inspection, testing or management, work costing $10 000 or more, 5 per cent.

For work costing less than $10 000, it is proper to charge a fee in excess of 5 per cent.

4. For full professional services and management, including preliminary studies, detail drawings and specifications, awarding contracts, active and continuous supervision, testing and inspection, work costing $10 000 or more, 10 per cent.

For work costing less than $10 000 it is proper to charge a fee in excess of 10 per cent.

5. For investigations and reports involving questions in dispute and intended for use in connection with expert testimony:

Charges, a minimum fee or retainer of $100 to $500, or such larger amount as may be commensurate with the financial importance of the case or the labor involved, with *per diem* and expense charges as per paragraph No. 1, (*a*).

6. Where a *per diem* charge is made, six hours of actual work shall be considered one day. While absent from the home city, however, or while attending court, each day of twenty-four hours or part of a day shall be considered one day, irrespective of the actual hours of time devoted to the case.

7. When charges are based on a percentage of the cost, the commissions as above are to be computed on the entire cost of the complete work, or on the estimated cost pending execution or completion. Payments shall be made to the engineer from time to time in proportion to the amount of work he has done.

8. Traveling expenses as well as any expenses involved in the collection of the data necessary for the proper designing or planning of the structure or project, such as borings, soundings, or other tests, and excepting only ordinary measurements and surveys, are to be paid by the client in addition to the commission herein provided for.

9. When alterations or additions are made to contracts, drawings or specifications, or when services are required in connection with legal proceedings, failure of contractors, franchises or right of way, a charge based upon

the time and trouble involved shall be made for same, in addition to the commission herein provided for.

10. Drawings and specifications are to be considered the property of the engineer, but the client is entitled to receive one complete record copy of same upon payment of actual cost of making copies, if no duplicate set is on hand.

APPENDIX "B."

Canons of Professional Ethics adopted by the Bar Association of the City of Boston, April 10, 1909.

Preface.

The American Bar Association, at its thirty-first annual meeting, held at Seattle, Wash., on August 27, 1908, adopted thirty-two canons of professional ethics. The Bar Association of the City of Boston, at its stated meeting held on April 10, 1909, adopted the thirty-four canons of professional ethics which follow. The adoption of these canons was recommended by the Council, copies were distributed before the meeting among the members of the Association, notice was given that the meeting would be asked to act on their adoption, and they were adopted without a dissenting vote.

Most of the canons adopted by this Association are taken word for word from those adopted by the American Bar Association.

By order of the Council,

ROBERT S. GORHAM, *Secretary.*

VI.

Adverse Influences and Conflicting Interests.

It is the duty of a lawyer at the time of retainer to disclose to the client all the circumstances of his relations to the parties and any interest in or connection with the controversy which might influence the client in the selection of counsel.

It is unprofessional to represent conflicting interests except by express consent of all concerned, given after a full disclosure of the facts. Within the meaning of this canon, a lawyer represents conflicting interests when, in behalf of one client, it is his duty to contend for that which duty to another client requires him to oppose.

The obligation to represent the client with undivided fidelity and not to divulge his secrets or confidences forbids also the subsequent acceptance of retainers or employment from others in matters adversely affecting any interest of the client with respect to which confidence has been reposed.

VII.

Professional Colleagues and Conflicts of Opinion.

A client's proffer of assistance of additional counsel should not be regarded as evidence of want of confidence, but the matter should be left to the determination of the client. A lawyer should decline association as colleague if it is objectionable to the original counsel, but if the lawyer first retained is relieved, another may come into the case.

When lawyers jointly associated in a cause cannot agree as to any matter vital to the interest of the client, the conflict of opinion should be frankly stated to him for his final determination. His decision should be accepted unless the nature of the difference makes it impracticable for the lawyer whose judgment has been overruled to coöperate effectively. In this event it is his duty to ask the client to relieve him.

Efforts, direct or indirect, in any way to encroach upon the business of another lawyer are unworthy of those who should be brethren at the Bar; but, nevertheless, it is the right of any lawyer, without fear or favor, to give proper advice to those seeking relief against unfaithful or neglectful counsel, generally after communication with the lawyer of whom the complaint is made.

VIII.

Advising upon the Merits of a Client's Cause.

A lawyer should endeavor to obtain full knowledge of his client's cause before advising thereon, and he is bound to give a candid opinion of the merits and probable result of pending or contemplated litigation. The miscarriages to which justice is subject, by reason of surprises and disappointments in evidence and witnesses, and through mistakes of juries and errors of Courts, even though only occasional, admonish lawyers to beware of bold and confident assurances to clients, especially where the employment may depend upon such assurance. Whenever the controversy will admit of fair adjustment, the client should be advised to avoid or to end the litigation.

IX.

Negotiations with Opposite Party.

A lawyer should not in any way communicate upon the subject of controversy with a party represented by counsel, much less should he undertake to negotiate or compromise the matter with him, but should deal only with his counsel. It is incumbent upon the lawyer most particularly to avoid everything that may tend to mislead a party not represented by counsel, and he should not undertake to advise him as to the law.

X.

Acquiring Interest in Litigation.

The lawyer should not purchase any interest in the subject matter of the litigation which he is conducting.

XII.

Fixing the Amount of the Fee.

In fixing fees, lawyers should avoid charges which overestimate their advice and services, as well as those which undervalue them. A client's ability to pay cannot justify a charge in excess of the value of the service, though his poverty may require a less charge, or even none at all. The reasonable requests of brother lawyers, and of their widows and orphans without ample means, should receive special and kindly consideration.

In determining the amount of the fee, it is proper to consider: (1) The time and labor required, the novelty and difficulty of the questions involved,

and the skill requisite properly to conduct the cause; (2) whether the acceptance of employment in the particular case will preclude the lawyer's appearance for others in cases likely to arise out of the transaction, and in which there is a reasonable expectation that otherwise he would be employed, or will involve the loss of other business while employed in the particular case or antagonisms with other clients; (3) the customary charges of the Bar for similar services; (4) the amount involved in the controversy and the benefits resulting to the client from the services; (5) the contingency or the certainty of the compensation; and (6) the character of the employment, whether casual or for an established and constant client. No one of these considerations in itself is controlling. They are mere guides in ascertaining the real value of the service.

In fixing fees, it should never be forgotten that the profession is a branch of the administration of justice and not a mere money-getting trade.

XIII.

Contingent Fees.

A client may have a meritorious cause of action and yet have no other means with which to pay the fees of counsel. In such a case it is proper for a lawyer to agree that he will make no charge for his services unless the litigation proves successful. To this extent contingent fees may properly be contracted for. But it is not proper for counsel to contract with the client either at the time he is retained or subsequently that he shall receive for his services a certain fractional part or per cent. of the amount recovered. The evil tendencies of such dealings with the client are plain. They tend to promote litigation and to degrade the practice of the law from an honorable profession to a money-getting trade; they involve a transaction between counsel and client in which their interests are opposed, in which the lawyer's knowledge and experience give him an advantage, and in which he is tempted to overreach the client; a speedy settlement may yield the lawyer a return out of all proportion to the labor expended, and this may tempt him to advise such a settlement for his own benefit and against the real interest of his client; moreover, the lawyer becomes to all intents and purposes a party in the cause, which impairs his capacity to advise wisely and exposes him to all the temptations to which parties are exposed to be unfair or dishonorable in the preparation and trial of their cases.

XIV.

Suing a Client for a Fee.

Controversies with clients concerning compensation are to be avoided by the lawyer so far as shall be compatible with his self-respect and with his right to receive reasonable recompense for his services; and lawsuits with clients should be resorted to only to prevent injustice, imposition, or fraud.

XV.

How Far a Lawyer may go in Supporting a Client's Cause.

Nothing operates more certainly to create or to foster popular prejudice against lawyers as a class and to deprive the profession of that full measure of public esteem and confidence which belongs to the proper discharge of its duties than does the false claim, often set up by the unscrupulous in defense

of questionable transactions, that it is the duty of the lawyer to do whatever may enable him to succeed in winning his client's cause.

The lawyer owes " entire devotion to the interest of the client, warm zeal in the maintenance and defense of his rights, and the exertion of his utmost learning and ability," to the end that nothing be taken or be withheld from him save by the rules of law legally applied. No fear of judicial disfavor or public unpopularity should restrain him from the full discharge of his duty. In the judicial forum the client is entitled to the benefit of any and every remedy and defense that is authorized by the law of the land, and he may expect his lawyer to assert every such remedy or defense. But it is steadfastly to be borne in mind that the great trust of the lawyer is to be performed within and not without the bounds of the law. The office of attorney does not permit, much less does it demand of him, for any client, violation of law or any manner of fraud or chicane. He must obey his own conscience and not that of his client.

XVII.

Restraining Clients from Improprieties.

A lawyer should use his best efforts to restrain and to prevent his clients from doing those things which the lawyer himself ought not to do, particularly with reference to their conduct towards Courts, judicial officers, jurors, witnesses, and suitors. If a client persists in such wrong-doing, the lawyer should terminate their relation.

XVIII.

Ill Feeling and Personalities between Advocates.

Clients, not lawyers, are the litigants. Whatever may be the ill-feeling existing between clients, it should not be allowed to influence counsel in their conduct and demeanor toward each other or toward suitors in the case. All personalities between counsel should be scrupulously avoided. In the trial of a cause it is indecent to allude to the personal history or the personal peculiarities and idiosyncrasies of counsel on the other side. Personal colloquies between counsel which cause delay and promote unseemly wrangling should also be carefully avoided.

XXI.

Newspaper Discussion of Pending Litigation.

Newspaper publications by a lawyer as to pending or anticipated litigation may interfere with a fair trial in the courts and otherwise prejudice the due administration of justice. Generally they are to be condemned. If the extreme circumstances of a particular case justify a statement to the public, it is unprofessional to make it anonymously. An *ex parte* reference to the facts should not go beyond quotation from the records and papers on file in the court; but even in extreme cases it is better to avoid any *ex parte* statement.

XXII.

Punctuality and Expedition.

It is the duty of the lawyer not only to his client, but also to the Courts and to the public, to be punctual in attendance, and to be concise and direct in the trial and disposition of causes.

XXIII.

Candor and Fairness.

The conduct of the lawyer before the Court and with other lawyers should be characterized by candor and fairness.

It is unprofessional and dishonorable for the lawyer knowingly to misquote the contents of a paper, the testimony of a witness, the language or the argument of opposing counsel, or the language of a decision or a text-book; or with knowledge of its invalidity to cite as authority a decision that has been overruled, or a statute that has been repealed; or in argument to assert as a fact that which has not been proved; or to deal other than candidly with the facts in taking the statements of witnesses, in drawing affidavits and other documents, and in the presentation of causes.

A lawyer should not offer evidence which he knows the Court should reject, in order to get the same before the jury by argument for its admissibility, nor should he address to the judge arguments upon any point not properly calling for determination by him. Neither should he introduce into an argument, addressed to the Court, remarks or statements intended to influence the jury or bystanders.

These and all kindred practices are unprofessional and unworthy of an officer of the law charged, as is the lawyer, with the duty of aiding in the administration of justice.

XXVI.

Taking Technical Advantage of Opposite Counsel; Agreements with Him.

A lawyer should not ignore known customs of practice of the Bar or of a particular Court, even when the law permits, without giving timely notice to the opposing counsel. As far as possible, important agreements, affecting the rights of clients, should be reduced to writing; but it is dishonorable to avoid performance of an agreement fairly made because it is not reduced to writing, as required by statute or rules of Court.

XXVIII.

Advertising, Direct of Indirect.

The most worthy and effective advertisement possible, even for a young lawyer, and especially with his brother lawyers, is the establishment of a well-merited reputation for professional capacity and fidelity to trust. This cannot be forced, but must be the outcome of character and conduct. The publication or circulation of ordinary simple business cards, being a matter of personal taste or local custom, and sometimes of convenience, is not *per se* improper. But solicitation of business by circulars or advertisements, or by personal communications or interviews, not warranted by personal relations, is unprofessional. Indirect advertisement for business by furnishing or inspiring newspaper comments concerning causes in which the lawyer has been or is engaged, or concerning the manner of their conduct, the magnitude of the interests involved, the importance of the lawyer's positions, and all other like self-laudation defy the traditions and lower the tone of our high calling and are intolerable.

XXX.

Upholding the Honor of the Profession.

Lawyers should expose without fear or favor before the proper tribunals corrupt or dishonest conduct in the profession, and should accept without hesitation employment against a member of the Bar who has wronged his client. The counsel upon the trial of a cause in which perjury has been committed owe it to the profession and to the public to bring the matter to the knowledge of the prosecuting authorities. The lawyer should aid in guarding the Bar against the admission to the profession of candidates unfit or unqualified because deficient in either moral character or education. He should strive at all times to uphold the honor and to maintain the dignity of the profession and to improve not only the law, but the administration of justice.

XXXI.

Justifiable and Unjustifiable Litigations.

The lawyer must decline to conduct a civil cause or to make a defense when convinced that it is intended merely to harass or to injure the opposite party or to work oppression or wrong. But otherwise it is his right, and, having accepted retainer, it becomes his duty to insist upon the judgment of the Court as to the legal merits of his client's claim. His appearance in Court should be deemed equivalent to an assertion on his honor that in his opinion his client's case is one proper for judicial determination.

XXXII.

Responsibility for Litigation.

No lawyer is obliged to act either as adviser or advocate for every person who may wish to become his client. He has the right to decline employment. Every lawyer upon his own responsibility must decide what business he will accept as counsel, what causes he will bring into court for plaintiffs, what cases he will contest in court for defendants. The responsibility for advising questionable transactions, for bringing questionable suits, for urging questionable defenses, is the lawyer's responsibility. He cannot escape it by urging as an excuse that he is only following his client's instructions.

XXXIII.

The Lawyer's Duty in Its Last Analysis.

No client, corporate or individual, however powerful, nor any cause civil or political, however important, is entitled to receive, nor should any lawyer render, any service or advice involving disloyalty to the law whose ministers we are, or disrespect of the judicial office, which we are bound to uphold, or corruption of any person or persons exercising a public office or private trust or deception or betrayal of the public. When rendering any such improper service or advice, the lawyer invites and merits stern and just condemnation. Correspondingly, he advances the honor of his profession and the best interests of his client when he renders service or gives advice tending to impress upon the client and his undertaking exact compliance with the strictest principles of moral law. He must also observe and advise his client to observe the statute law, though until a statute shall

have been construed and interpreted by competent adjudication he is free and is entitled to advise as to its validity and as to what he conscientiously believes to be its just meaning and extent. But, above all, a lawyer will find his highest honor in a deserved reputation for fidelity to private trust and to public duty, as an honest man and as a patriotic and loyal citizen.

APPENDIX "C."

Code of Ethics of The Massachusetts Medical Society.

The Code is intended to establish certain general principles and rules of action for the Fellows of the Society.

I.

Physicians should encourage sound medical learning, and uphold in the community correct views of the powers and limitations of the science and art of medicine.

II.

The success of physicians depends upon their moral character, scientific attainments, industry and business talent. The kind of competition considered honorable in purely business transactions cannot exist among physicians without diminishing their usefulness and lowering the dignity and standing of the profession.

III.

The first duty of physicians is to their patients, who have a right to expect that their diseases will be thoroughly and confidentially investigated and properly treated, and that their mental peculiarities or infirmities will receive charitable consideration.

IV.

Physicians in their professional relations should be governed by strict rules of honor and courtesy. Their conduct toward each other should be such as to secure mutual confidence and good will.

Physicians should take no steps with a view directly or indirectly to divert to themselves the patients or practice of others.

They should not consent, except in cases of pressing emergency, to take charge of a patient when another is in attendance, until such attendant has been notified.

When called in cases of accident or other emergency they should relinquish them to the usual attendant, as soon as he is able to take charge.

V.

Consultations should be encouraged in cases of doubt or of unusual responsibility. The aim should be to give patients the advantage of collective skill. Discussions should be confidential. Consulting physicians should not say nor do anything to impair the confidence of patients or their attendants in the attending physicians.

VI.

Fee-tables have a local application only, and are designed to indicate reasonable charges for services. But with the understanding and consent of

their patients beforehand, physicians may place any value upon their services deemed proper.

VII.

Physicians should endeavor to establish and maintain clear distinctions between legitimate medicine and quackery. They should not countenance secret remedies; nor be interested in proprietary preparations; nor receive commissions from apothecaries; nor advertise their methods of practice, or free consultations, or free distributions of medicines to the poor.

APPENDIX "D."

CODE OF ETHICS SUGGESTED FOR THE BOSTON SOCIETY OF CIVIL ENGINEERS.

THE code is intended to establish certain general principles and rules of action for the members of the Society.

I.

Engineers should encourage sound engineering learning and training in the scientific schools and in actual work.

II.

The success of engineers depends upon their moral character, scientific attainments, industry, integrity and business talent. The kind of competition considered honorable in purely business transactions cannot exist among engineers without diminishing their usefulness and lowering the dignity and standing of the profession.

III.

The first duty of engineers is to their clients, who have a right to expect that that portion of their business entrusted to the engineer will receive very careful investigation and intelligent treatment and that such information derived by the engineer, which is peculiar to that business, will be considered as confidential.

IV.

Engineers in their professional relations should be governed by strict rules of honor and courtesy. Their conduct toward each other should be such as to secure mutual confidence and good will.

a. They should take no step with a view to divert to themselves the clients or work of other engineers.

b. If for any good reason a client should desire to transfer his work to another engineer, it is his privilege to do so, but the engineer in charge should be given notice, with the reason for the same, of such change by the client, and the engineer to whom it is transferred should, before accepting the work, communicate with the engineer in charge, in order that there may be no bad feeling caused through misunderstanding.

c. All communications shall be made through the responsible head, unless others are designated to act for the principals.

d. No attempt should be made to secure the services of assistants of other engineers, without communicating first with the principal in order to see that such action will not embarrass him.

e. No assistant should contract to go with another engineer without first consulting with his superior.

f. A superior should not stand in the way of advancement of a subordinate.

g. The criticism of another's work should be broad and generous. The success of one member brings credit to the profession, and the failure of one, discredit to the whole.

h. The attitude of superiors to subordinates should be that of helpfulness and encouragement.

The attitude of subordinates to superiors should not be one of constant criticism.

The treatment of each to the other should be open and frank.

i. The engineer should be willing to assume his proper share of public work and render such assistance as is possible for the general good of the community.

V.

Consultations should be encouraged in cases of doubt or unusual responsibility. The aim should be to give the client the advantage of collective skill. Discussions should be confidential. Consulting engineers should not say or do anything to impair the confidence in the regular engineer, unless it is apparent that he is wholly incompetent.

VI.

Schedules of fees have local application only and are designed to show reasonable charges for service in such locations. With the understanding and consent of their clients, engineers may beforehand place any value on their services deemed proper.

VII.

Engineers should, so far as possible, not be interested in any mercantile enterprises which will prevent them from giving an unprejudiced opinion on appliances to be used in their work.

They should not receive commissions for materials, appliances or labor entering into the work under their supervision.

In advertising, they should avoid, as much as possible, any impression of commercialism.

VIII.

The attitude of engineers toward contractors should be one of helpfulness and tactfulness, combined with just and firm criticism.

IX.

As the lines of distinction between the various branches are becoming less marked, an intimate relation of the various branches should be encouraged.

[NOTE. — Discussion of this paper is invited, to be received by Fred. Brooks, Secretary, 31 Milk Street, Boston, by May 1, 1912, for publication in a subsequent number of the JOURNAL.]

IMPORTANCE OF THE HIGH TEST OF CO_2 IN BOILER FLUE GASES AND AUTOMATIC ANALYSIS AND RECORD OF SAME.

By Abram T. Baldwin, Member of the Detroit Engineering Society.

[Read before the Society, December 1, 1911.]

In considering the subject of this paper, there are a number of points of view that one should take in order to approach it broadly. Naturally, the point which the manufacturer first considers is that of economy to himself. Should we not all consider also whether our action affects our city in which the plant is located? If it is possible to make a city more cleanly, more beautiful and more healthful, the problem should be more interesting to the manufacturer. This can be accomplished by the abatement of smoke, which is part of the combustion problem. It is also economical to the people of a city on account of damage done to various dry goods, clothes and buildings.

The third consideration is that of the effect on our nation, for when it is considered that there is a waste to-day of anywhere from 10 to 30 per cent. of the coal used, the effect upon the future cost should be earnestly taken into consideration by every one.

Therefore the economical burning of coal accomplishes three important results: it saves money for the manufacturer and individual; it assists in maintaining a clean, beautiful and healthful city; third, it protects our nation and assists our country in maintaining its splendid position before the world, and at the same time keeps the commodity coal down to a minimum cost.

The problem of coal economy and utilization of heat developed has had as much thought and energy put into it as any given problem before engineers in the present or past, and yet it has been determined that a further saving of from 10 to 30 per cent. can be made. Actually, there is but about 5 per cent. of the total energy in coal that is saved. In other words, the losses that occur between mine and product amount to 95 per cent. It is, without doubt, possible in considering the first problem brought to a manufacturer, that is, the economical burning of coal, to save an immense part of this loss. It seems strange

that what one at this age of mechanical perfection would think would have been the first problem to be considered is only now being taken up. It rather looks as if it were a case of the cart before the horse; for I think you will quite agree with me that the various means for the economical handling of coal, the different automatic stokers, superheaters, mechanical draft devices, automatic blowers, each of these either dealing with the saving of labor in the handling of coal or the saving of steam after it is developed, should rather have come after than before the economical burning of coal, or the development of the maximum quantity of heat in the coal after its delivery to the furnace of any given plant. Is it not to-day entirely and absolutely up to the judgment of the individual how he will manipulate these various devices in order to obtain what he individually thinks is the best condition of firing to maintain any given steam pressure? Have we given the fireman previously to this any positive means whereby to govern his actions? It is right at this point, that is, in the control of combustion chamber elements, that these economies may be effected.

The subject of coal analysis and purchase of same might easily take up an entire paper, but as this problem is so absolutely connected with that of combustion, there are a number of points that I wish to present for your consideration. What is your object in purchasing coal? The answer seems quite obvious, for it is the heat that it will develop in the given boiler or boilers under your control that is required. But is this view considered always when purchases are made? Is it not too often that coal is purchased according to price irrespectively of quality? And yet it may be more economical to the purchaser to buy higher priced or lower priced coal in order that he may obtain from his individual boiler plant the highest efficiency possible. In coal there are six principal elements: carbon, volatile matter, hydrogen, moisture, ash and sulphur. The first three, when the problem is considered from the individual element point of view, might be considered to be heat-producing. For the time being we will call them such. The latter three, moisture, ash and sulphur, might be termed adulterants. Consider for a moment the moisture, — but need I go any further? — that when one buys coal, one does not require water, is so obvious that it requires no further argument. The second, ash, produces no heat, increases the proportion of every ton carried from mine to boiler house, as well as decreases the capacity of the furnace. Ash in coal varies from 5 to 25 per cent. There-

fore you can see immediately that it bears an important relation when considering the purchase of a suitable coal. Sulphur produces clinkers, and is, therefore, injurious. That leaves the carbon, volatile matter and hydrogen to consider. The volatile matter forms the hydrocarbons, and produces heat. Hydrogen, when combined with oxygen, produces heat. In this action 62 500 B.t.u.'s are produced, but its per cent. in coal is small. Therefore there remains the principal element, carbon in coal, as the real developer of available heat units.

To avoid detail as much as possible in consideration of this problem of the calorific value of a coal, is not this definition correct? The net calorific value of a fuel should be expressed in terms of the sample as received, should include a deduction for the heat carried off by the water vapor formed from both the moisture and the hydrogen in the coal, and should express the net heat in a fuel which is available for evaporative purposes. To explain this more fully I will present an example: The gross calorific power of a dried coal sample, which included 8 per cent. moisture and 5 per cent. hydrogen (mark you, this is on the dry sample) was 13 000 B.t.u.'s; the gross calorific power of the coal as received was 11 960 B.t.u.'s; the net calorific power of the dried coal was 12 565 B.t.u.'s, but the net calorific power of the coal as received, which represented the actual available heat per pound of coal, was 11 482 B.t.u.'s. Without the measurement of moisture and its deduction for hydrogen, the calorific figures are misleading, and what should be compared is the net figure when prices are considered. Secondly, the percentage of ash in the coal, while reflected in a sense in the calorific power, is of importance because it is in a measure a guide as to the suitability of coal for a particular set of furnaces. I bring these facts to your consideration to bring out more forcibly that there is one correct method of determining the calorific value of a coal, and also to bring to your earnest attention the importance of purchasing coal not alone on the basis of price, but on its net calorific value.

Every boiler has a given grate area per unit of heat surface, and there is one coal which will give the most economical results and the highest efficiency for that boiler under those given conditions.

I would like to bring for a moment to your attention the consideration of the chemical actions taking place in the burning of coal.

Table showing how to Ascertain the Theoretical Amount of Air Required for the Complete Combustion of a Fuel, the Carbon and Hydrogen in which are Known.

Carbon. — The atomic weight of carbon is 12, and of oxygen 16; and 2 atoms of oxygen are needed to form CO_2 with 1 atom of C.

$\therefore$ 12 : 32 = 1 : 2.666.

$\therefore$ 1 lb. C requires 2.666 lb. O.

Hydrogen. — The atomic weight of hydrogen is 1, and of oxygen 16; and the water formed has 2 atoms of H and 1 atom of O.

$\therefore$ 2 : 16 = 1 : 8.

$\therefore$ 1 lb. H. requires 8 lb. O.

Now the ratio of air to oxygen by weight is 4.315.

$\therefore$ 1 lb. C requires $2.666 \times 4.315 = 11.503$ lb.

and 1 lb. H requires $8 \times 4.315 = 34.520$ lb.

Apply this to a coal containing 76.54 per cent. of carbon and 5.56 per cent. of hydrogen —

$$\left.\begin{array}{ll} C \ldots & 0.7654 \times 11.503 = 8.804 \\ H \ldots & 0.0560 \times 34.520 = 1.930 \end{array}\right\} = 10.734 \text{ lb.}$$

It may be stated that 1 lb. of air = about 12 cu. ft.

If the green gases are not supplied with proper secondary air to effect their combustion the nascent flame becomes extinguished, and soot is formed and deposited in part upon the boiler plates, rendering the conduction of these bad in the extreme [see table] and partly carried away as black smoke.

Table showing the Loss in Conductivity of Boiler Plate Due to Different Thickness of Soot Deposit.*

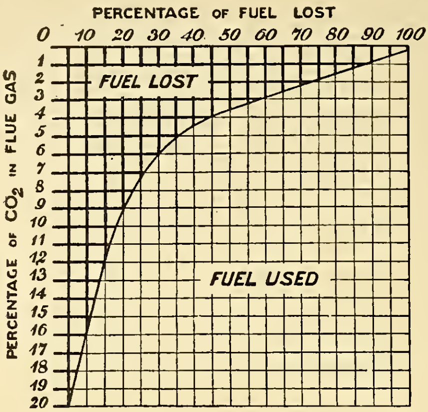
Thickness of Soot.	Loss, per Cent.
Clean plate	0.0
1-32d inch	9.5
1-16th inch	26.2
1-8th inch	45.2
3-16ths inch	69.0

* Proceedings, Institution of Marine Engineers, January 6, 1908.

Table.

The figures show the percentage loss in coal as a result of the flue gas having a percentage of CO_2 and a temperature as per the intersecting columns. The air temperature is assumed to be 60 degrees fahr.

Percentage of CO_2.	300° fahr.	420° fahr.	540° fahr. } Temperature of Waste Gases.
4	39.40	59.00	78.8
5	32.00	48.00	64.0
6	26.30	39.50	52.6
7	22.50	33.75	45.0
8	19.70	29.50	39.4
9	17.52	26.28	35.0
10	15.77	23.65	31.5
11	14.33	21.50	28.6
12	13.14	19.70	26.3
13	12.10	18.15	24 0
14	11.25	16.90	22.5
15	10.50	15.75	21.0



STANDARD DIAGRAM SHOWING HOW FUEL LOSS *increases* AS PERCENTAGE OF CO_2 *decreases*, ON THE ASSUMPTION THAT THE FURNACE GASES LEAVE THE MAIN FLUE AT NORMAL WORKING TEMPERATURE.

From the point of view of coal analysis and net calorific value, the important element in coal is carbon; consequently, in its combustion, the per cent. of combined carbon and oxygen as CO_2 in the resultant gases is also of the greatest importance. Consider these three problems — in boiler work there are three principal elements in the consideration of combustion — there are others, it is quite true, but these three seem to stand out as being of most importance; first, the quality of coal; second, the amount of coal, or thickness of fuel bed you deliver to a furnace; third, the differential pressure between what might be termed base of stack and ash pit; in other words, the draft, or suction. Consider first that there is being charged to a furnace a given quantity of coal at a given thickness of fuel bed; also that you have a constant vacuum within the combustion chamber. Now vary the coal in quality as delivered to the furnace, and then as to size. The per cent. of CO_2 in the resultant gases then will vary as the carbon in the coal and inversely as the size. Consequently you can determine by the aid of a CO_2 recorder varying qualities of coal as delivered to the furnace. The second problem is with a uniform coal, varying the thickness of fuel bed or amount charged to furnace and maintaining a uniform suction in combustion chamber; again the CO_2 will vary according to the varying amounts of coal charged, and by this means the proper speed of stoker may be determined, and the proper thickness of fuel bed. Thirdly, with a uniform quality of coal and a given speed of stoker and thickness of fuel bed, then

vary the vacuum in combustion chamber; the CO_2 in the resultant gases will again change as the draft. Therefore, you will see that by the determination of the per cent. of CO_2 you will be able to determine, first, what the quality of your coal is; secondly, what the proper speed of stoker is; and, thirdly, the proper draft under which to operate.

Where do the coal losses take place? The first is in the failure to use the maximum B.t.u.'s in the coal you burn, or, in other words, to extract from every pound of coal its maximum potential energy. The second is in the failure to utilize the maximum amount of sensible heat of the resultant gases of combustion.

What are the causes for the failure to utilize all the heat units in a pound of coal? The first is the lack of knowledge of the calorific value of the coal as delivered to your boiler. Second, lack of proper furnace and boiler construction; and in this latter would be the control of the governing elements such as the proper coal feed, the even distribution of fuel bed, uniform supply of air and proper amount of air to any given section of fuel bed, the correct distance from fuel bed to heating surface, and sufficient combustion chamber area to give time for thorough mixture of gases in order that the maximum heat might be developed preliminary to their coming in contact with the boiler tubes. The third cause is the incomplete absorption by the water of the sensible heat of the gases. Fourth, the lack of sufficient and accurate apparatus for the determination of the various results obtained from the control of those points mentioned in the first, second and third causes, in other words, apparatus for the determination and record of the per cent. of CO_2 in the resultant gases, accurate recording pyrometers, accurate measurements of coal and water. All of these pieces of apparatus have now been developed and are in constant use to-day.

Thus we have determined where these losses occur, the causes for the losses, and naturally the next question would be how we can overcome them. The first cause for failure that I stated was the lack of knowledge of the calorific value of the fuel delivered to the boilers in question. Let me ask still a further question. Is this fuel delivered the most economical for the given grate area per unit of heating surface for the boiler in question? If the boiler has a large grate area per unit of heating surface and the demand for steam consumption is well within its rating, then it may pay to purchase coal of a low calorific value.

The second cause that I presented was lack of proper fur-

nace and boiler construction and control. We might say that this is the key to the whole situation, and in order to present the point well, I will give you an idea of what some of the companies are doing in order to obtain proper control. Some little time ago I visited a power company of Chicago and there saw an installation consisting of a Babcock & Wilcox boiler with a Green Chain grate. The nearest point of the bridge wall of this furnace was within 3 inches of the grate, and just at a point where the grate started over on the rear end. With this construction it was absolutely impossible to obtain a high per cent. of CO_2 on this boiler for the reason that if the coal was thoroughly consumed by the time it reached the discharging point of the grate, the space between the grate and bridge wall would not be completely closed, and consequently the amount of air passing through the ashes at this point and between the ashes and the bridge wall would simply be a diluent for the gases of combustion, extracting the heat from them instead of being a necessary supply for the incomplete gas formed as CO, and thus adding temperature to the resultant gases. What was done in this case to obtain 12 to 14 per cent. CO_2 was to extend the bridge wall forward 3 links, or 18 in., making the vertical distance between the grate and bridge wall 4 in. in place of 3 in.

The aim in this case was to make a coal seal at a point on the grate just before the last of the coal or coke would pass to discharging end of the grate. By using particular care in the construction of the grate, where the grate came in contact with side walls of the furnace every pound of air then would have to pass through some part of the coal bed.

Watching the coal feed and air supply, keeping both as constant as possible, they were able to maintain a very uniform test of CO_2 at about 12 per cent. and with practically no other attention to boiler. In ten hours during the day's run the fuel bed would not be barred or cleaned of clinker. On this furnace previously to their moving up the bridge wall the test of CO_2 ran at 6 to 7 per cent. There is, therefore, a saving by that which is represented of from 5 to 6 per cent. of CO_2. This calculated to per cent. of coal amounts to 11 per cent. About the same time that I visited this plant I called at another that had just installed a CO_2 recorder on an absolutely new and up-to-date plant. Here it was found practically impossible, except for a few individual tests, to obtain a higher per cent. than 8 per cent. CO_2. There was great irregularity in the tests, the variation being from 5 to 8. This plant I did not visit until all the boilers

were in run and so did not have opportunity to inspect the construction of the combustion chamber and grate. I was told by the engineer in charge that the conclusion had been reached through the aid of the CO_2 recorder that an error had been made in the distance between bridge wall and grate of 2 in. in width by 120 in. in length, and that the bridge wall had been ordered changed and brought closer to the grate by 2 in. This same company has six different plants, every one of which uses CO_2 recorders for determining combustion efficiencies.

During the early part of 1910 in a plant in which there were 24 Babcock & Wilcox boilers of 278 h.p. rating at 11 sq. ft. of heating surface per horse-power, each unit of three boilers having one economizer for each of the three boilers discharging to a main flue, and from this a single flue in which the economizer was placed, the gas then passing to the main collector and so to the stack, a series of nine experiments was made in order to determine the most efficient boiler rating and the correct grate area in order that the highest efficiency might be obtained. These boilers were equipped with Roney Stokers. The three experiments consisted in operating the boilers at respectively 120 per cent., 100 per cent. and 80 per cent. of their rating, with a reduction of grate area from 68 to 51 sq. ft. The original ratio of heating surface to grate area was 45 to 1. The final ratio and most efficient was 60 to 1. Every precaution possible was taken to insure accurate results. Blow-off pipes were slip-blanked, special volumetric water measurements were made, coal sampling was made most carefully, the general sample being divided into four samples and each being completely analyzed. Hocking Valley slack, one half fine and one half coarse, was used, Precision Simmance-Abady combustion recorders were used, and Hoskins recording pyrometers. Three experiments were made at each of the three ratings. The summary of the efficiencies that were obtained of the respective ratings, 80, 100, 120 per cent., was 71.81, 68.57, 67.49 boiler efficiency. The summary of these tests I have here and I will give the conclusions reached and changes made in this boiler house. There was obtained by these changes an over-all efficiency of about 81 per cent., this being maintained throughout the past year, 1911. The over-all efficiency includes boiler and economizer. They were able to produce a minimum saving in this plant of 10 per cent. This has actually been substantiated by the coal used per ton of product produced.

To summarize, first, Precision Simmance-Abady CO_2

recorders are used continuously in this plant, one recorder being installed on each unit of three boilers and so connected that it can be thrown on to each individual boiler and connected just previous to and after the economizer. They are usually run on the collected gases from the three boilers. The connections to the economizer are for the purpose of determining air infiltration by the percentage of CO_2 obtained. Their percentage of CO_2 has been increased from 7 or 8 per cent. to 12 per cent. and over, and the men are paid on a premium basis on every per cent. obtained over 12. Every man in the boiler house shares in this premium.

Second, the Hoskins recording pyrometer is used whereby the temperatures are studied and are continuously taken. The temperatures taken are of the gases from the boilers on entering and leaving the economizers.

Third, grate area has been diminished from 68 to 51 sq. ft., the original ratio being 45 to 1, the present and most efficient ratio being 60 to 1. That is ratio of heating surface to grate area.

Fourth, all settings, economizers, steam drums were covered with $\frac{3}{4}$ of an inch of asbestos cement plastered on with trowel, outside of which was placed a course of hollow brick.

Fifth, Foster superheaters were installed, which secured 40 to 50 degrees cent. superheat at boilers in place of steam which previously carried about 3 per cent. of moisture.

There is a very important point in these experiments that should be mentioned independently of the data. It is also a point that can be made the subject of a special investigation. The point is this, — that when the grate area was reduced from 68 sq. ft. to 51 sq. ft., what was actually done was to increase the combustion chamber volume per square foot of grate area. In this consideration the per cent. volatile should most certainly be very carefully analyzed, for with a long flame coal or that which would contain a high volatile, — say, 35 per cent., — the combustion chamber area should be much larger than with a short flame coal, or one that would contain, say, 20 to 25 per cent. volatile. This argument is supported by the results obtained by the two companies whose tests I am reporting to you.

I was in hopes to give you some definite information in regard to some experiments which are now being carried on by a power company at Detroit, Mich., pertaining to the exploration by gas analysis of the combustion chamber. I want to bring to your attention again what I have stated previously,

and that is the great importance that gas tests, and especially CO_2 tests, bear in power investigations. Practically all of this exploration of the combustion chamber is being approached from the point of view of per cent. of CO_2 at various points in the chamber. The investigations at the power company mentioned above take into consideration the complete analysis of the gas at various points in the entire combustion chamber. This installation is a Roney stoker as applied to a Babcock & Wilcox boiler.

They are investigating this subject with two ends in view. One, — to obtain from the boilers in their plant a greater capacity with the same or increased efficiency and greater economy on repairs, particularly as applied to the burning out of the arch-over grate. The arch is subject to a most severe heat. Its form, i. e., whether it is arched over the stoker or flat, bears a very important relation to the results obtained in the furnace. The depth of the arch into the furnace bears an important relation to the gases of combustion. It has been found in exploration of the combustion chamber that the resultant gases of combustion seem to take different courses in the combustion chamber, and the analyses of these gases showed a very great difference in the percentages of CO_2, CO and O. The Roney stoker, as formerly constructed, was divided in the middle by a wall and arched over each section of the stoker, there being steam tuyères in the arch delivering steam just over the top of the coal after it had entered the furnace, or just about at the point at which the volatile matter in the coal is being driven off. This seems to have very good results, for the gas at the top of the combustion chamber where it turns to make its second passage through the tubes analyzed about 16 or 17 per cent. CO_2, thus showing very complete combustion. Now, in place of this condition at the top of the furnace, the exploration of the combustion chamber at the lower end of the Roney stoker showed a very excessive amount of air. In this furnace there is an air duct directly back of the chamber grate at the bottom of the furnace. This air duct supplies through tuyères a certain amount of air at the bottom of the grate. Now, the analysis of these gases between the bottom of the grate and the tubes in the lower end of the first pass of tubes showed only 7 or 8 per cent. CO_2, the balance being oxygen, thus showing absolutely that there was a dilution of the gases by the air entering through the air duct at the bottom of the Roney grate. Now, what are those who are in control of this furnace doing to overcome these difficulties? In the first place, they are

making the arch extend all the way across the furnace, and perfectly flat, cutting off the division between the two sections of the stoker, also completing the stoker, where the dividing wall was, to the extreme width of the furnace, thus adding grate area. They are cutting off the air supply from the duct at the bottom of the grate; they are baffling back of the first row of tubes, their object being that the gases that would pass up the front and back of this baffle would pass to the second passage of the gas at approximately the same analysis of 16 to 17 per cent. CO_2. They have also increased the speed of the Roney stoker 20 per cent., and found that this gave very much better results, for the reason that when the stoker had a slow speed, the mechanical operation of the fingers, which rise and fall very slowly, tended to break up the fuel bed, causing fissures and allowing air to enter through these fissures instead of passing through the fuel bed. By increasing the speed of the stoker, they have kept the fuel bed in a very uniform condition throughout, the fissures do not open every time the fingers of the grate move, and the results obtained have been satisfactory. By this one change they have been able to increase the work done on the boiler.

The trouble in this case was due to a mechanical difficulty which allowed the air entrance to the combustion chamber without passage through the fuel bed. With these few illustrations of what companies are actually doing out in the field, you see the importance, first and foremost, of determinations of coal values by calorimetry, and second, of investigation of the boiler from the point of view of gas analysis and boiler efficiency. The higher efficiencies obtained to-day are going to be attained through the use of efficient recording and testing apparatus, which have made possible a more thorough study of coal and combustion chamber and boiler conditions.

(*a*) Siphon tank.
(*b*) Float.
(*c*) Chain.
(*d*) Extractor.
(*e*) Drip valve (water).
(*f*) Water feed.
(*g*) Siphon tube.
(*h*) Balance valve or change-over cock.
(*j*) Recorder bell and tank.
(*k*) Water tank.
(*l*) Overflow from KOH tank.
(*m*) Caustic potash (KOH) vessel.
(*n*) Scale.
(*o*) Overflow pipe.
(*p*) Flue gas inlet.
(p_1) Inlet for constant stream of gas.
(*q*) Balance weight.
(*s*) Suspension balance.
(*x*) Water inlet (furnishing motive power for the recorder and also drawing continuous stream of flue gas through p_1).
(*y*) Waste water outlet.

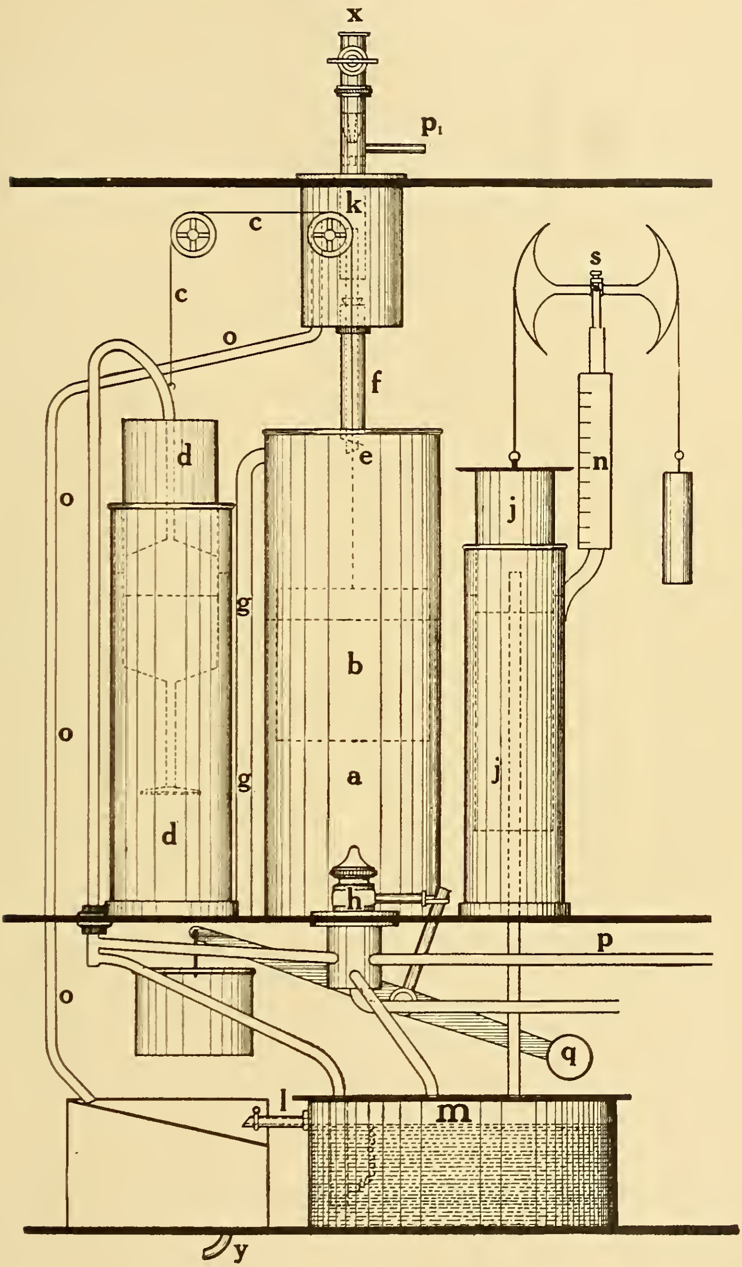


Fig. 1.

Precision Simmance-Abady CO_2 Recorder.

This sketch shows the whole of the working parts in position except the clock and pen.

Water is put into vessels (*d*) and (*j*) and caustic potash (KOH) into (*m*).

Operation of the Recorder.

A small stream of water is the motive power for effecting the cycle of operations described below.

Referring to the outline drawing on the preceding page, — which does not show the pen movement, — the principal parts of the apparatus are designated as follows:

(*a*) and (*b*) siphon tank and float.

(*d*) and (*d*) extractor tank and bell.

(*j*) and (*j*) recorder tank and bell (the latter counter-balanced).

(*h*) balance valve or 3-way cock.

(*m*) caustic potash vessel.

(*p*) gas connection from the boilers.

(*x*) water supply connection to the recorder. Tanks (*d*) and (*j*) contain enough water to properly seal the bells.

Water is allowed to flow through hollow valve stem (*e*), from the small reservoir (*k*), with safety overflow (*oo*). In siphon tank (*a*) there is a weighted float (*b*), which is attached by means of a chain (*c*) to the bell (*d*) of the extractor, and this float rises with the water, allowing the bell (*d*) to fall. At the top of its stroke, the float (*b*) raises the valve stem (*e*), thus tripping the valve, and momentarily flushing the siphon tank; the water now siphons out of (*a*) through siphon tube (*g*) and allows the weighted float to fall. As it falls it draws up the water sealed extractor bell (*d*), in which is created a partial vacuum, and into which, therefore, gas flows from the flue through (*p*) and (*h*). This may be called the beginning of the cycle.

Next, the weight of the water which has flowed from the siphon tube (*g*) into the small pot beneath it overcomes the weight of the counter (*q*) and closes the balance valve (*h*), thereby cutting off a definite sample of the gas. Water is released from the small pot in time to allow the valve to open at the proper interval.

The stream of water is continually flowing into the tank (*a*), and the float (*b*) rises again, which allows the extractor bell (*d*) to sink. As it sinks, it will be seen that the gas in bell (*d*) (which by the closing of the valve (*h*) is now uninfluenced by vacuum or other conditions in the flue), is first reduced to atmospheric pressure, and is then actually under pressure; the volume of the gas is, therefore, forced into vessel (*m*), where it bubbles up through the caustic so that CO_2 is absorbed, and thence into the recorder (*j*), raising the bell.

The boxwood scale (n) at the side of the recorder tank is graduated from 100 per cent. at the bottom to 0 per cent. CO_2 at the top, and the capacity of the bell (d) is such that when the apparatus is run on air, containing practically no CO_2, the total volume is transferred to the recorder bell (j), which in this case rises to the zero point. When flue gas is admitted to the apparatus, exactly the same quantity (i. e., enough to send recorder bell up from 100 to 0) is passed from the extractor bell (b), but on the passage of the gas, the CO_2 is absorbed by the caustic potash in iron vessel (m), reducing the volume of the gas; owing to such absorption the recorder bell (j) will not rise to its full height. We allow it to automatically rise as far as it will, and a pen then marks on a chart its final position. *The percentage of CO_2 in the gas is thus automatically recorded.* This bell (j) then vents, discharging the analyzed gas through the 3-way cock, so that it does not mix with or come in contact with the fresh charge of gas, which is dealt with in exactly the same way, the whole operation, as well as the continuous drawing forward of the flue gas, taking place automatically by means of the stream of water.

For the purpose of bringing along a constant supply of gas, below the cock (x) is an injector or aspirator, attached to the top of the case; (p_1) is an auxiliary gas connection to the aspirator from the main inlet pipe (p). *By this means, gas is continuously exhausted from the pipes connecting recorder to boilers*, so that the successive samples analyzed from the instrument are from the boiler flue, and not stagnant gases in the connecting pipes. The injector is worked by the small stream of water (the motive power for the recorder) connected at (x) before this enters the top tank of the recorder so that no extra water is used for this continuous pump. Two glass bottles are fixed in connection with the injector as safeguards. A glance at one shows whether the flue gas pipes are clear of obstruction, and the other shows that the stream of gas is being maintained.

The working of recorder can be seen all the time, so that although the instrument is in a locked case, yet the firemen can see what effect they are producing and regulate their work accordingly.

The accuracy of recorder can be checked at any moment by opening a tap and drawing in air instead of flue gas, when the apparatus will indicate zero (i. e., no percentage of CO_2). There is no troublesome adjustment, no continuous changing of chemical

solution, no glycerine, oil or other similar liquids; but the apparatus is always accurate and unaffected by temperature, evaporation and all the dusty conditions of a boiler-house, and it contains no perishable parts.

Practically the only attention necessary is, —

		Time Taken.
(*a*)	Once a day; put ink in pen and tear off chart......	½ minute.
(*b*)	Once a week; wind the clock....................	½ minute.
(*c*)	Once a month; renew the solution...............	5 minutes.
(*d*)	Six times a year; put on fresh roll of charts.......	2 minutes.

Notes on Connecting CO_2 Recorder to Boilers.

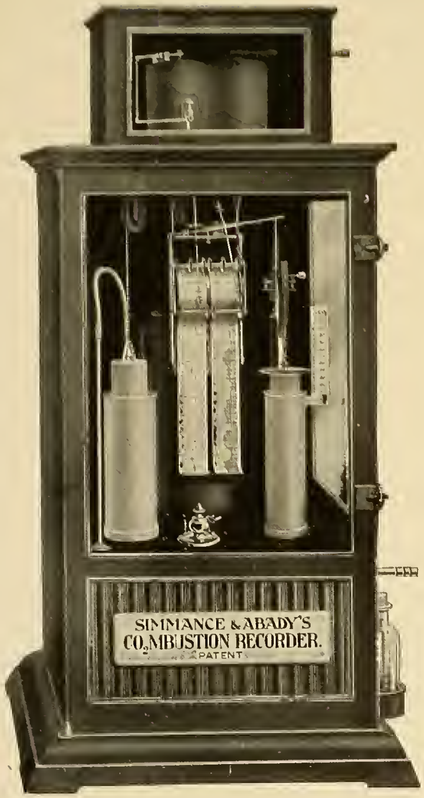
A CO_2 recorder being fitted in connection with boilers, continually drawing forward hot and dusty gases, it will readily be seen that unless precautions were taken the pipes would become stopped with dust and condensation. A simple and positive system of filtering and condensing which prevents all possibility of pipe stoppage is illustrated in Figs. 2 and 3.

A ½-in. or ¾-in. pipe called the "bus" pipe or header (*a*) is run along the battery of boilers, with a tee opposite sampling tubes from each boiler but no valves or cocks. On each of these tees is screwed a small cast-iron oil cup (*b*), a cap (*c*) is dropped over the inner tube shown in Fig. 2, and a little lubricating oil is poured into the cup, thus sealing it. Into each flue is inserted a length of perforated iron pipe, and on the end of each of these flue pipes or sampling tubes is also screwed an oil cup (*b*) with cap (*c*), sealed with oil. We have now means of making connection from any boiler to the "bus" pipe. A filter (*o*), Fig. 3 (filled with excelsior, glass wool, cotton waste, pumice stone, as most convenient), is placed in the oil cup (*b*) of the boiler it is desired to test, after having removed the cap (*c*), the channel of the filter is also filled with oil. A piece of muslin is placed over the excelsior or other filtering material in filter as shown in Fig. 3.

DISCUSSION.

Mr. W. P. Putnam. — The importance of keeping a close check on boiler-room operations has been clearly outlined in an admirable manner by Mr. Baldwin, in his presentation of the subject of CO_2 recorders. To my mind this problem of combustion is a most interesting one, not only from a scientific standpoint, but also from the economics involved. For the engineer who is dealing with combustion problems it is most encouraging to know that plant managers are rapidly realizing

Dust Filter and Connections for Precision Simmance-Abady CO_2 Recorder.



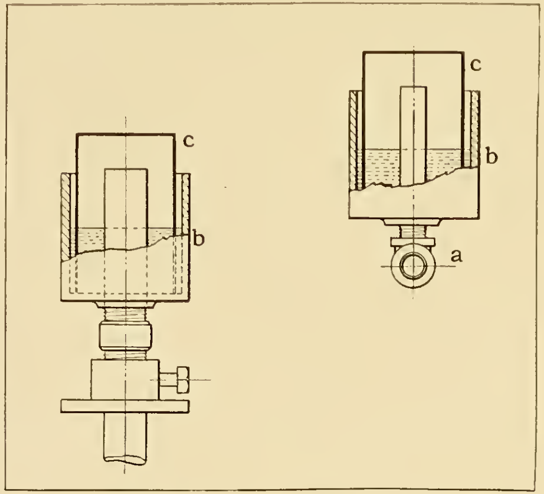


Fig. 2. Boiler shut off from CO_2 Recorder by Caps (*c*) in Oil Cups (*b*) on Boiler "Offtake" and "Bus" Pipe (*a*).

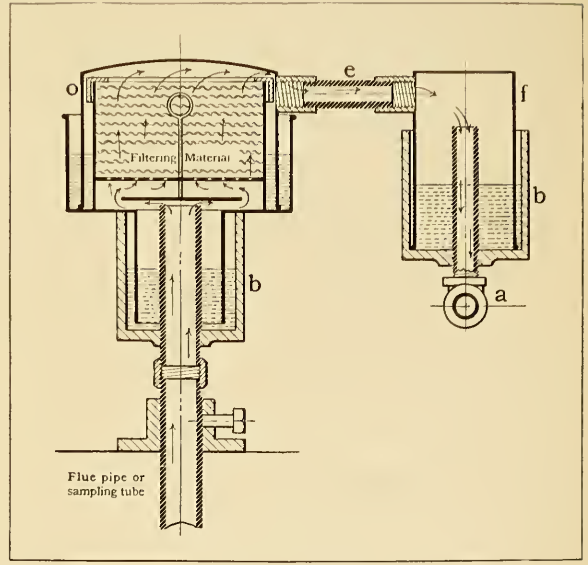


Fig. 3. Boiler connected to CO_2 Recorder by Removing Caps (*c*) and Inserting Filter (*o*) and Cover (*f*) in the Oil Cups (*b*), and Coupling Pipe in Flue to "Bus" Pipe (*a*).

that in the boiler room they must adopt modern methods to obtain uniform results.

The installation of automatic stokers, fuel economizers, forced draught and recording instruments for the measurement of stack draught, draught over the fire grate, percentage of CO_2 in the stack gases, temperature of exit gases and temperature of the feed water have accomplished wonders in producing steam under trying conditions. Much has been done; much still remains to be accomplished.

When we realize that from 9 to 10 lb. of water are evaporated from and at 212 degrees fahr. into steam, per pound of coal burned, under favorable installations, we are at once cognizant of the great waste that is going on every day in the conversion of the energy in the coal into steam.

I have been much interested in the work that Messrs. Bone & McCourt are doing with their flameless combustion furnaces. The principle of burning gaseous fuel under pressure without flame is indeed most interesting. The modern adaptation of Sir Humphry Davy's discovery may help to solve some of our perplexing smoke problems even if it does not accomplish such great economies as the inventors claim.

The great waste of fuel, due to crude methods in burning it, the great damage to property due to smoky furnaces that pollute the atmosphere, destroying fabrics, vegetation and human life, are surely phases of this important combustion problem that must claim the attention of all engineers interested in the welfare of our community. To my mind, any one who is devoting his energies to help solve these problems is a public benefactor, and should be encouraged in his work. Mr. Baldwin is to be congratulated on the way he is treating these vital points in the economics of burning coal.

[NOTE. — Discussion of this paper is invited, to be received by Fred. Brooks, Secretary, 31 Milk Street, Boston, by May 1, 1912, for publication in a subsequent number of the JOURNAL.]

ANNUAL ADDRESS.

By D. C. Henny, President Oregon Society of Engineers.

[Read before the Society, February 5, 1912.]

To the Members of the Oregon Society of Engineers:

It is with sincere regret that, through absence from Portland, I find myself unable to be present at this annual meeting. I have, therefore, requested the Secretary to read to you the few remarks which I would have preferred to make to you in person.

A year ago, when our society was organized, there was abundant enthusiasm, and large numbers of applicants for membership were not lacking; yet there was some doubt in the minds of many of us whether we could achieve success at once, — although of the ultimate success of an engineering society in a city like Portland, the financial and intellectual center of an immense and fast-growing tributary territory, there can be no question.

We may well pause, therefore, at the end of the first year of our society's existence, to ask whether reasonable expectations have been fairly realized.

The great activity in engineering construction, both in the city itself and in this state and neighboring states, had brought together here a large number of engineers belonging to every branch of the profession. Railroad building into Central Oregon and through Central Washington proceeded at a rapid pace, as did the construction of hydro-electric power plants and electric railroads. Large irrigation works were being built, and liberal appropriations, granted by Congress, were being expended upon the improvement of the mouth and channel of the Columbia River and on the Celilo lock canal. Most of this work, so far as it extended throughout Oregon and into Eastern Washington and Idaho, was managed from Portland as a center, and contributed to the immediate growth of this city, as did the general influx from the East of settlers into the Columbia and Snake River basins. The rapid city growth, as well as the gradually awakening confidence in the future greatness of Portland, resulted in unprecedented activity in city engineering construction, such as paving, improvement of

additions, street-car extensions, and enlargement of domestic water supply. This condition of development, which is but a phase and beginning of the future commercial history of the Pacific Coast, had rapidly brought together a number of engineers in Portland, so large as to be surprising to those of older residence here, as was evident when our first meeting was called, at which organization was effected. In a sense it was a heterogeneous gathering, for we were practically unknown to one another. We all felt the need of getting together, the necessity of common action to make our influence felt for the good of the community, and the desire to benefit from each other's experience.

Under these circumstances, organization was accomplished with unexpected promptness, and a constitution was adopted which fixes a high standard for our objects and aims.

Since that time the society has started on its career in a most promising way. Monthly meetings have been held, at which papers were presented and discussed, — of an unusually wide range. They led us from engineering works in our immediate vicinity — such as the Clackamas Power Dam — to works in the eastern United States and to the Panama Canal, and to a review of engineering prospects in South America and in China.

Desirable and economical publication of these papers has been provided through the Society's joining the Association of Engineering Societies, whose JOURNAL gives us the advantage of nation-wide circulation, as well as receipt of papers read before a large number of sister societies.

We have taken our place among other civic bodies in the state by exerting our influence in public matters, such as the prevention of undesirable water legislation. Other steps have been taken to enlarge the beneficial activity of our society, as, for instance, through the inauguration of an employment bureau, and the arranging for a separate engineering section in the new public library.

It is, therefore, evident that a promising beginning has been made. In reviewing these matters I have been most strongly impressed with the fact that the credit for what has been accomplished has been due almost exclusively to the Executive Board and the members of the various committees, who have enthusiastically done their duty, often at serious personal sacrifice. In that respect I do not believe that our society differs materially from many other societies of a similar character. It appears to be human nature that a member of any community or organization considers his duties fully discharged by a conscientious vote

at election time, after which the existence of any further obligation is completely dismissed from his mind. If it is human nature, it may be useless to attempt to bring about any change. Yet I cannot feel that in a truly democratic organization, as our society should be, the highest success can ever be reached unless each member gives some additional thought to the welfare of the entire body and to the manner in which he personally can advance its interests. At each meeting, why should not many more than has been the case in the past come forward with suggestions, leading to greater accomplishment? In the matter of papers to be read, why should not each member consider whether he or any of his immediate acquaintances has any subject of interest to present before the society, and thus render less onerous and difficult the work of program committees. Why should not some member bring before the society, and through the society before the public, such matters as the unwisdom of paying its public engineering officers at a rate far below the importance of their positions and the magnitude of the funds they have to handle. All these things are in the interest of our society, of the profession and of society at large.

As before stated, a certain amount of apathy on the part of individual members of any organization seems to find its source in human nature, and yet I believe it possible to mend this condition to some extent, when the necessity for it to insure complete success is fully realized; and it is hoped that especially the younger members, from whom we are glad to hear at all times, will take these remarks to heart.

It is expected that the social feature of our society, as exemplified by our gathering this evening, will be more fully developed during the coming year, as it is one of the most effective methods of getting together and becoming acquainted, and thus more nearly attaining one of the objects for which we have organized.

The details of the society's work will be presented to you in the reports of the secretary and the treasurer.

Under the constitution, the tenure of office of one vice-president, the secretary and the treasurer, expires to-night, as well as of the nominating committee. Tellers have been appointed to render report to this meeting of the result of balloting for the election of new officers, and this report will be read. The general interest shown in this election is in itself gratifying.

It is with a feeling of sorrow that I recall to your minds the death, early last year and shortly after organization had

been perfected, of Mr. W. H. Corbett, one of our vice-presidents. Suitable resolutions were passed at the time and were communicated to the family and to the public press.

I take this occasion to thank you for the courteous manner in which you have made my work easy and pleasant, and to express my confidence in the future success of this society.

OBITUARY.

Lyman Luville Gerry.

Member of the Boston Society of Civil Engineers.

Lyman Luville Gerry was born in Oxford, Me., August 4, 1857. He was the son of Lyman and Harriet Bonney Gerry. He had been obliged to retire from active work in his profession in the spring of 1909 on account of his health. His death occurred July 15, 1911, at the Boston City Hospital, where he had undergone a surgical operation.

Mr. Gerry was a student of civil engineering for three years at the Massachusetts Institute of Technology. Immediately after leaving the Institute he was employed on railroad work in New York State. He was afterwards connected with Percy M. Blake & Co., of Hyde Park, and while with this firm he was employed in and superintended the construction of many water-works systems in North Attleboro, Turners Falls and Stoneham in Massachusetts, in Dover, N. H., and in other places. He was the city engineer of Dover, N. H., for five years.

In 1897 Mr. Gerry came to the Massachusetts Highway Commission, and until the time of his retirement from active work in 1909 he was employed with the Commission as resident engineer on state highway construction, and had charge of numerous contracts during these years for macadam and gravel roads in what is known as the Second Division of the state, which includes the roads between the Hoosac Mountains on the west and the towns of Groton and Ayer on the east, also including roads in the Connecticut Valley section. Mr. Gerry's judgment as a road-builder was excellent, and the state is indebted to him for some of its best highways. He built a number of concrete bridges on these highways which are recognized as first-class examples of structures of this type, and which show the result of insistence upon careful work and finish.

Mr. Gerry was married at Stoneham, November 23, 1887, to Miss Delia Couture, of Turners Falls, Mass. He was a member of the First Unitarian Church of Stoneham. He held high positions in many fraternal organizations, was a member of the Benevolent Order of Elks, of the Odd Fellows, and of the

American Numismatic Association. He was also a member of the New England Water Works Association, and was for twenty-four years a member of the Boston Society of Civil Engineers. He was for many years a resident of Stoneham, and at one time was superintendent of streets of that town. He had a large acquaintance among men in official life, and was much respected by his associates for his intelligence and integrity.

ANDREW M. LOVIS, *Committee.*

ASSOCIATION
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Organized 1881.

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THE LATEST INCANDESCENT LAMP.

BY EVAN J. EDWARDS.

[Read before the Detroit Engineering Society, January 19, 1912.]

AN incandescent electric lamp may be defined as a mechanism which produces light by means of an electrically heated body enclosed within a transparent evacuated envelope. The fundamental principles of operation of an incandescent lamp are, of course, very simple. A body when sufficiently heated will give off what we call light. Therefore, in order to produce light it is only necessary to heat a body, and to take the proper precautions to prevent oxidation. An incandescent electric lamp, then, reduced to its simplest terms, is but a bit of matter, enclosed in a transparent evacuated bulb, and provided with outside contacts for connection to an electric circuit, which will supply the energy necessary for maintaining a high temperature.

The principle of operation of the tungsten filament lamp is the same as that conceived in the mind of Mr. Edison, previous to the production of his first incandescent lamp, more than thirty years ago. However, the working out of the details that have brought about a lamp which is commercially efficient and which will remain operative a satisfactory period of time, and which can be produced cheaply, has occupied the best thought and effort of hundreds of men.

This paper is an attempt to go somewhat into detail as to the factors which are concerned in the making of incandescent lamps, to enumerate several of the most important processes

involved in the manufacture and testing of lamps, and to discuss the general properties of the finished product.

Light may be defined, subjectively, as that form of radiant energy which is capable of producing a sensation in the eye. It is known to include but a comparatively small range of wave lengths in a very large series. All radiation is supposed to be a kind of electro-magnetic disturbance which is propagated through the ether and the so-called transparent substances as media. This disturbance travels in waves, always at about the same velocity (188 000 miles per second), but having different wave lengths and consequently different frequencies. Radiation of all these wave lengths which are known to exist and all combinations of wave lengths manifest themselves in different ways.

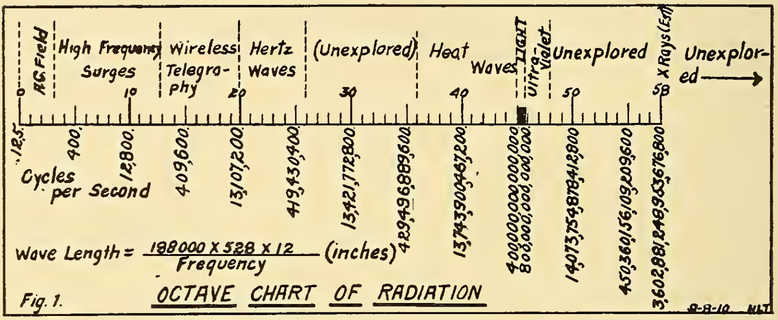


Fig. 1.

The chart of Fig. 1 shows all possible frequencies of radiation from the 25 cycles per second of the low-frequency alternating current field up to the highest known frequency of the x-ray. It is interesting to note the very small range of frequency which constitutes light.

Radiation is brought about in many ways. There is the simplest case of radiation from all heated bodies, also the radiation set up by an oscillating alternating current field, as of the wireless transmitter, and again the radiation from luminescent gases, such as in the Moore tube, as well as some cold forms of chemically caused radiation, such as the light given by the firefly.

Radiation which is of the proper wave length to be manifested as light may be produced in many different ways, and again the most convenient and simplest is the heated body. Such radiation is called "temperature radiation," and it is the particular kind with which we have to do in discussing the subject of incandescent lamps.

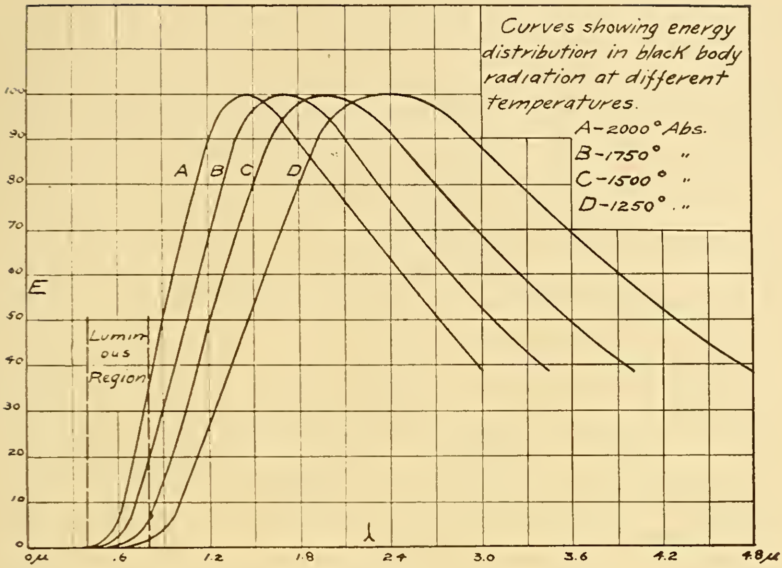


FIG. 2.

Various materials behave differently as regards their radiation properties when heated. It was shown by Kirchoff that the ability of a body to radiate energy is measured by its ability to absorb the radiant energy which falls upon it. A perfect absorber would be a perfect radiator. A theoretically perfect radiator and absorber is called a " black body," and the character of the radiation, " black body radiation." Although no such body exists, the conditions can be very closely approximated by heating a retort which is enclosed with the exception of a very small opening for the escape of the radiation to be investigated. Since the inner walls are compelled to absorb all the radiation except the very small portion which escapes, the theoretical requirements are fulfilled. A study of the behavior of the theoretical black body is useful in investigating the available materials. By referring to the curves of Figs. 2 and 3 the effect of temperature on the distribution of the

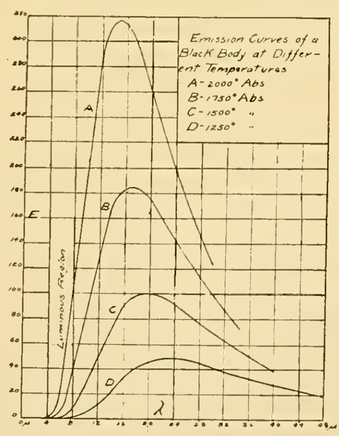


FIG. 3.

energy at the various wave lengths will be noted. Fig. 2 is for constant maximum ordinates and Fig. 3 for the same piece of material raised to various temperatures. As the temperature is increased the maximum ordinate travels toward the shorter wave lengths and it is seen that at a temperature of about 5 000 degrees cent. the maximum lies within the visible spectrum.

Since all available radiators are limited to working temperatures far below 5 000 degrees, it is seen that the maximum efficiency temperature of light production cannot be reached, and the higher the temperature which is obtainable the better will be

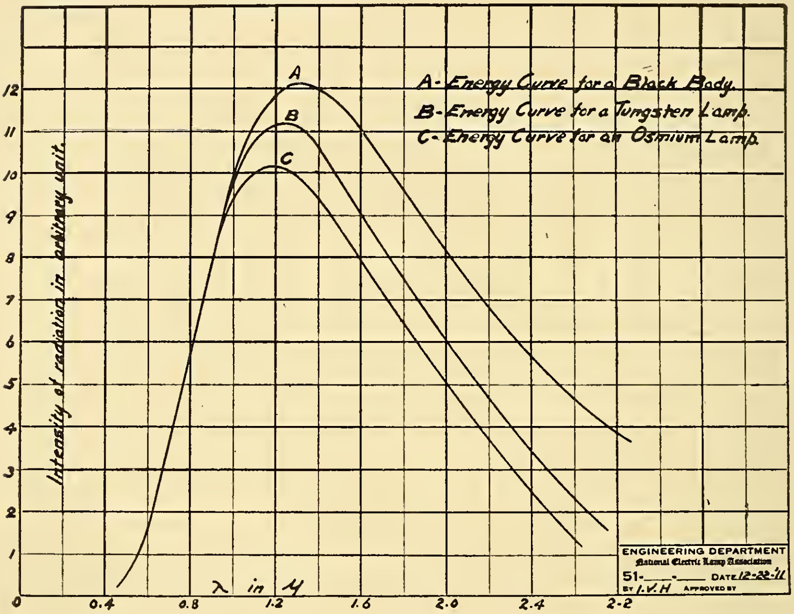


FIG. 4.

the efficiency of the production of light by temperature radiation. This principle holds for all practical radiators although they do not have exactly the same energy-temperature relations as those shown for the black body.

Bodies which are not perfect absorbers are known as gray bodies or colored bodies according to their characteristics. Such bodies must be maintained at a higher temperature in order to radiate energy at the same rate as the black body, and moreover they may show a different distribution of energy over the various wave lengths. It is easily seen that if for a given energy radiated

in the visible spectrum, less is radiated at other wave lengths, the efficiency of light production will be increased. Obviously, a radiation characteristic of this kind is desirable in a lamp filament material. Such an energy curve is illustrated by Fig. 4, which shows the energy curves of tungsten and osmium as compared with the theoretical black body. This property is called "selectivity," and such a radiation, "selective radiation."

The ideal radiator for an incandescent lamp would be one which would radiate all the supplied energy in the visible spectrum. No material known will even approximate that condition at any temperature. But with the materials available for incandescent lamp filaments, there are two main avenues of approach to improvement of efficiency. They are higher temperature, and a higher degree of selectivity. A lamp filament material should most of all be capable of withstanding a high temperature, and in addition it is desirable that it should be a selective radiator. Filament materials disintegrate at temperatures far below their melting points, and the rate of disintegration depends largely on the vapor tension for the material and the temperature of operation. Carbon, for example, fulfills the condition of high melting point better than any other known material, but is sadly lacking in the requirements as regards the low vapor tension. A carbon filament must be operated far below its melting point in order that the rate of disintegration be not excessive.

The ideal filament material would possess certain other properties than those concerned with the efficiency of radiation. The material should have such physical properties as will allow of easy handling and mounting in the bulb. A filament in the form of a continuous flexible wire is the most convenient to handle, and in order to be put in such form must be ductile. The mechanical strength should be high so that the finished lamp will be rugged and applicable to the various classes of service. The material should possess certain resistance characteristics. The limit of sizes of lamps which can be made for a given voltage is determined largely by the specific resistance of the material. A low-resistance material means a long slender filament, and the limits are fixed by the degree of fineness to which the material can be drawn and by the mechanical strength of the wire when made very small. Again, if the material were of too high a resistance, the filament would become so short that a large percentage of the supplied energy would escape by conduction along the leading-in wires. The resistance temperature char-

acteristics must be such that the operation will be stable, that is, the voltage must increase with increase of current. Since lamps are always subject to variations in voltage, it is to advantage to have a marked positive temperature coefficient, for if the resistance increase with temperature, current will not increase or decrease as rapidly as does the voltage, and the change in luminous intensity and the effect on the life of the lamp will, in consequence, be rendered less marked.

Very extensive search has been made during the past thirty years for a material which will most nearly fulfill the requirements just enumerated. A great number have been tried and found wanting. Only a few years ago, before any of the metals were successfully used as filament materials, a great scientist made the statement that it was highly improbable that any more suitable material than carbon would ever be found. The fact that carbon was known to have a melting point higher than any known metal and that it had survived as the only practical filament material for so many years in the face of all the investigation which had been made, no doubt lead him to the conclusion. No more refractory material than carbon has yet been found, but the lower vapor tension of the heavy metals allows practical operation at a temperature much closer to the melting point. The greater the atomic weight of a metal the lower the vapor tension expected of it.

Mendelejeff was first to arrange the elements on a diagram according to their atomic weights and their melting points. Such an arrangement is shown in Fig. 5. It is seen that the points representing the various elements suggest the existence of some kind of a periodic law. It would be expected that the metals best adapted for use as filaments would be found on the peaks of the curve and, moreover, toward the high atomic weight side of the figure. If this figure and the knowledge of to-day were available thirty years ago the search of the investigators of that time might have been directed at once to such metals as molybdenum, tantalum, tungsten and osmium, as well as to carbon, and little of their time would have been spent with such metals as nickel, iron, cobalt and the different alloys which were experimented with.

Osmium and tungsten have proved to be the two filament materials which are best adapted to use as filament materials. There is a possibility that a more refractory and more stable metal may be found, as is suggested by the so-called " periodic law " curve. It would have an atomic weight midway between

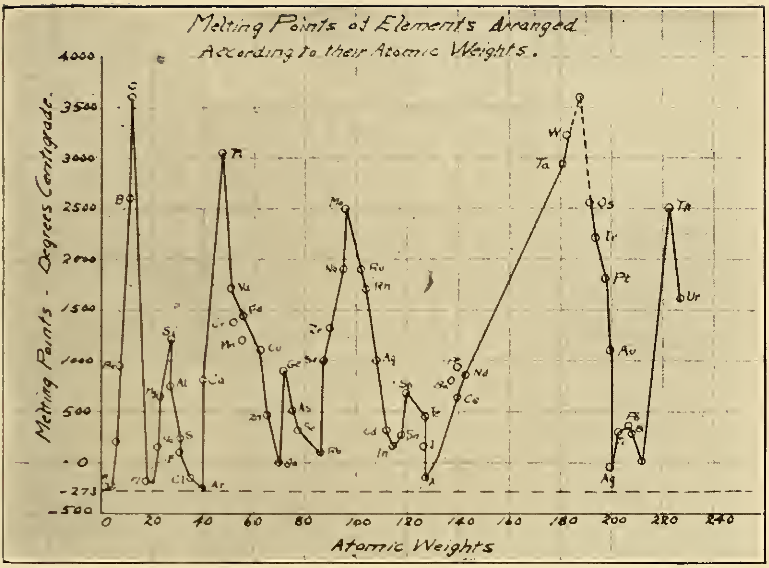

Melting Points of Elements Arranged
According to their Atomic Weights.
Melting Points - Degrees Centigrade.
Atomic Weights
4000
3500
3000
2500
2000
1500
1000
500
0
-273
-500
0
20
40
60
80
100
120
140
160
180
200
220
240

FIG. 5.

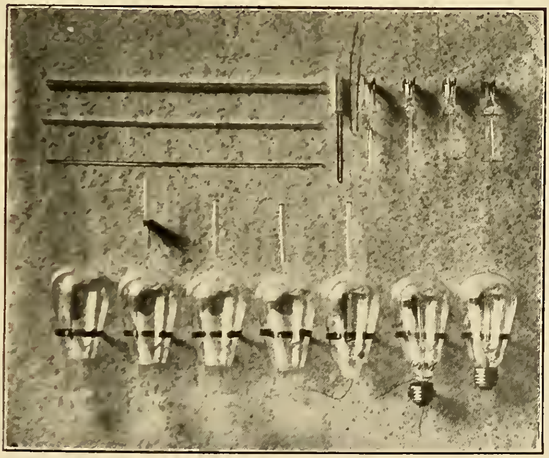


FIG. 6.

osmium and tungsten, and a boiling point around 3 600 degrees cent., as shown by the point reached by the dotted portion of the curve.

Osmium is nearly equal to tungsten in its ability to withstand high temperatures, and superior to tungsten as a radiator because of its greater selectivity, but is ruled out because the metal is not available in sufficient quantities for general use. This leaves tungsten the undisputed position of the best available filament material of the present.

Inherently, it possesses certain adverse properties which for a time taxed the ingenuity of the investigators to the extreme. It has a very low specific resistance, which means long and thin filaments, and the investigator was confronted at once with the difficulties attendant on the shaping of the material into threads much finer than had ever been called for in the design of the higher resistance carbon lamps. Moreover, it was found that the metal was not ductile. A process was resorted to which involved mixing the powdered metal with a binder, then squirting through a diamond die, and later burning out the binder. In order to furnish the lamp with sufficient resistance and yet have a minimum number of pieces or loops of filament it was necessary to make the spans long. The resulting lamp was good except for the fact that it was easily broken. In spite of the difficulties which presented themselves to the early manufacturers of tungsten filament lamps, the lamp demonstrated at once its great superiority over its predecessors. It proved to be nearly three times as efficient, superior in color value, more stable in its operation on fluctuating voltage, and more nearly constant in luminous intensity throughout life.

Later it was discovered that with proper treatment tungsten became ductile and could be drawn into wire. To-day it is being drawn into all sizes ranging in diameter from less than one-thousandth of an inch for the lowest current lamps up to one-hundredth of an inch for some types of series lamps. One-thousandth of an inch is smaller than the diameter of a hair. Tungsten drawn wire is stronger than the strongest steel. The smaller sizes show a tensile strength of about 600 000 lb. to the square inch. Unfortunately, considerable of the strength is lost the first time the filament is heated to the working temperature, but fortunately it is still materially stronger than the filaments made by the squirting process. Also, the drawn filaments allow of a method of support which renders the lamps much more rugged. The spans are short and no welds are necessary.

The electrical design of tungsten filament lamps is very simple. It has been seen that the ability of a given filament material to radiate energy depends on the temperature. It also, of course, depends on the extent of the surface area from which the radiation can take place. A line of lamps which are to operate at the same efficiency will, obviously, operate at the same filament temperature, which in turn means that they will be operating at the same power per unit of filament area. Lamps of a given filament material are designed to operate at various voltages consuming a considerable range of power, but the condition of a given power per unit of filament area always abides within certain very narrow limits which are fixed by considerations of most economical life.

The resistance of the filament depends on the specific resistance of the material and on its dimensions. The amount of light given is directly proportional to the filament area, other things being constant. For a given efficiency the current for a given diameter of filament is always the same. Likewise, the voltage per unit length of a given diameter of filament is always the same.

The above simple relations may be expressed as follows, where D is diameter, L length, I current; E voltage and W wattage:

(1) $D = K_1 I^{\frac{2}{3}}$ for given efficiency, any wattage and voltage.
(2) $D = K_2 E^{-\frac{2}{3}}$ for given efficiency and given wattage.
(3) $D = K_3 W^{\frac{2}{3}}$ for given efficiency and voltage.
(4) $L = K_4 I^{-\frac{2}{3}}$ for given efficiency and wattage.
(5) $L = K_5 E^{\frac{2}{3}}$ for given efficiency and wattage.
(6) $L = K_6 W^{\frac{1}{3}}$ for given efficiency and wattage.

These equations are useful in comparing various designs of lamps for the purpose of gaining an idea of comparative dimensions of filaments. For example, it is seen that a 100-watt, 110-volt, lamp has a filament of 2.5 times the diameter and 6.3 times the cross section of the 25-watt. The current density in the 25-watt lamps is seen to be 1.6 times that for the 100-watt and nearly 3 times that for the 500-watt, which perhaps would not be expected at first thought. A 220-volt lamp has a filament 59 per cent. longer than the 110-volt lamp of the same wattage.

For purposes of design, the relations may be put in more convenient form. Only two equations are necessary. They are:

(7) $I = K_7 w^{\frac{3}{4}}$;
(8) $e = K_8 w^{\frac{1}{4}}$;

where w is the weight per unit length, and e is length per volt required. Equation (7) is obtained directly from (1), assuming only that the specific gravity is the same * for the various sizes. Equation (8) is obtained from equations (1), (4), (5) and (7). The reason for putting in this form will be evident.

The tungsten metal is drawn down to about the various sizes required. Sample lengths are then taken and cut to an exact length and weighed on a very delicate scale. One of these scales will weigh to the nearest one-hundredth of a milligram. The spool from which the sample is taken is then rated for current according to equation (7). Length per volt required is given by equation (8). If it is desired to produce a lamp of a certain candle-power and for a circuit of a given voltage, it is necessary first to obtain the wattage by multiplying the candle-power by the specific consumption, then the current by dividing the wattage by the voltage. Filament is chosen from a spool having the normal current rating as obtained by weighing a standard length, equal to that required for the lamp. The length is obtained by multiplying the length per volt as obtained previously for that spool, by the voltage. The design of the filament is then complete.

The method of supporting the filament is determined by the length which must be cared for. Bulb size is determined by experience factors. A small bulb has a smaller area upon which the particles gradually thrown off from the filament are deposited. Therefore, the candle-power will depreciate more rapidly for a small bulb. A very large bulb is inconvenient, unsightly and expensive.

The manufacture of drawn wire tungsten filament lamps, or "Mazda" lamps, as they are called, aside from the drawing of the wire, is a highly refined application of the art of glass working. A lamp factory makes use of four kinds of glass stock for the manufacture of a given type of lamp; the bulb, large tubing for the stem, small tubing for the tip, and the rod for the filament support. Fig. 6 shows this stock as well as various forms which it assumes in the process of manufacture.

There are in all thirty-two operations performed in the process of manufacture of a "Mazda" lamp aside from those necessary in the production of the filament wire. There are so many that time does not allow of all being considered in detail. Only the more important operations will be enumerated.

The glass bulb as it comes from the glass factory is but a

* Not strictly true, but nearly enough for most purposes.

bulb blown on the end of a tube. First a small hole is blown in the bulb at the point which is to become the tip of the lamp. The bulb is then tubulated, that is to say, a piece of small glass tubing is sealed to the bulb where the small hole was blown. Later this small tube is used for a connection to the exhaust pump. Next the large tube on the end of the bulb which is to become the base end of the lamp is cut off, leaving the bulb a given standard length.

Tubing for the stem of the lamp is cut into pieces of proper length and then flared on one end, the one which is to be sealed into the base of the bulb.

The small glass rod for holding the filament supporting hooks is cut to length and the upper and lower " buttons " formed.

Next, the supporting hooks are put into position in the glass buttons, after which the glass rod and leading-in wires are sealed into the unflared end of the stem.

The next operation is the winding of the wire on the supports. The filament is cut very accurately to the proper length, wound on the supports, and the ends fastened to the leading-in wires, especial pains being taken to properly distribute and adjust the slack.

The parts are then ready for the " sealing-in " operation. After inserting the filament barrel in the bulb, the flared end of the stem is sealed into the base of the bulb, after which the lamp is placed on the pump and evacuated. When the highest attainable vacuum has been attained the lamp is " tipped off," — that is, the small glass tube is cut off by heating it near the bulb, — thereby sealing the lamp and preserving the vacuum. The lamp is then finished with the exception of basing, which consists of putting on the base and soldering the leading-in wires to the contacts.

Twelve inspections are made during the process of manufacture of the lamp. Some are for the purpose of insuring a high standard of quality in the finished product and others are to prevent loss in the factory by continued work on lamps which are destined to be discarded in a final test or inspection.

In spite of the fact that all lamps are carefully designed for a given service, they cannot be depended upon to come within the desired limits of accuracy. So it is necessary to photometer all lamps in order that they may be properly labeled. Those falling outside certain limits are put into a class where they fit, or are discarded.

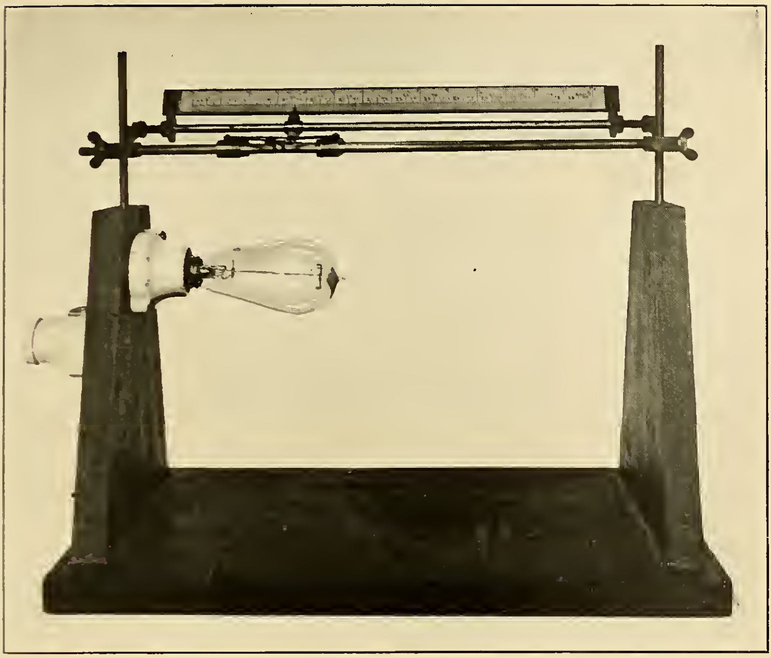


Fig. 7.
Device for Measuring Filament Position.

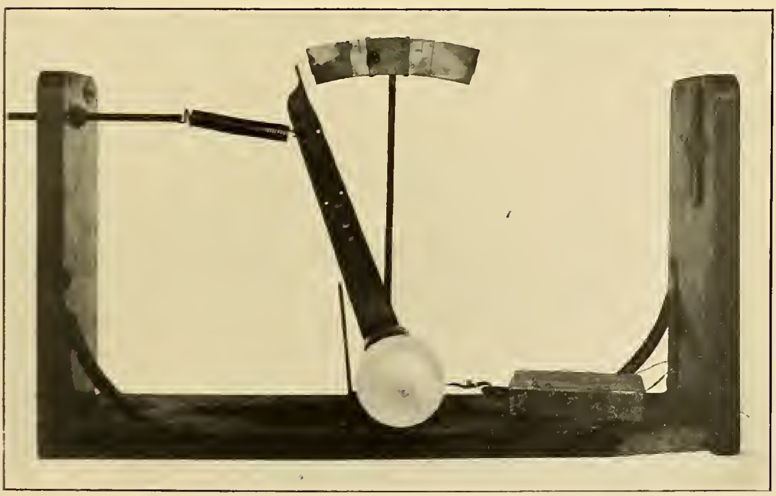


Fig. 8.
Base Torsion Testing Machine.

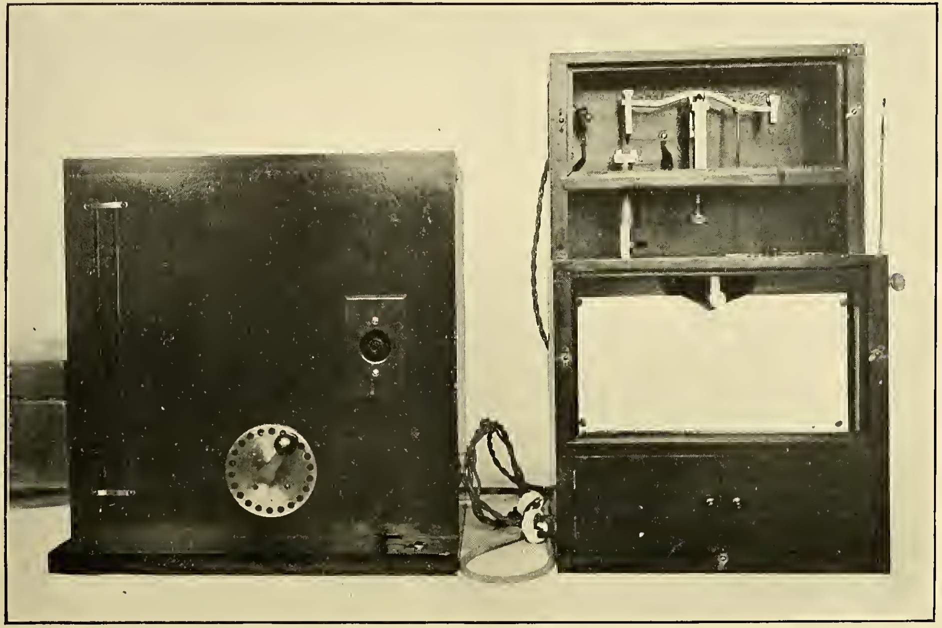


Fig. 9.

Machine for Measuring Tensile Strength and Breaking Load and Deflection of Filaments.

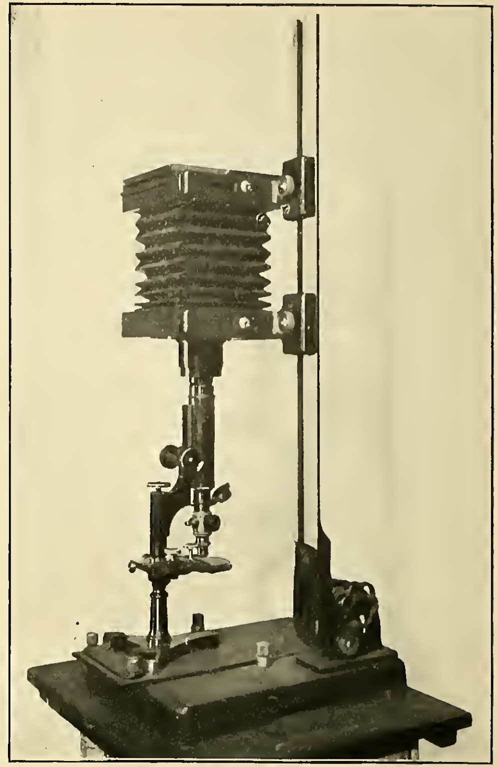


Fig. 10.

Micro-photographic Apparatus.

It may be interesting to note the various tests which are being constantly made upon the finished product by the manufacturers. They include life testing, base testing, checking of filament position, filament strength measurements, microphotography of filaments at various stages in life, etc. All these tests are conducted with extreme care. They furnish the manufacturers with full information as to progress along the lines of quality of the product, and provide them with a means of determining the effect of various methods and processes on experimental lamps. Besides the regular testing apparatus mentioned above there is, of course, a great deal of special equipment utilized in certain tests, which are not regularly made on the factory output. The photographs of Figs. 7 to 10 show equipment used regularly in testing.

The physical principles upon which the design and operation of lamps depend and the difficulties in manufacture are not of much interest to the average lamp user. He does not care particularly whether the lamp is selective in its radiation or not. It makes no difference to him, except as a matter of passing interest, just how many inspections or tests are made during the processes of manufacture. But he is very much interested in knowing what the lamp will do; that is to say, what may be expected of it under various conditions of service. What, then, are the operating characteristics of this lamp which we have called "The Latest Incandescent Lamp"? What happens when a voltage other than the normal value is impressed? How is it affected by the rapid and periodically varying voltage of the alternating current circuit? What fixes the operating efficiency which will give the best service? What particular advantages does it possess over its predecessors?

It is a matter of common knowledge that increasing the voltage on any incandescent lamp brings about an increase in the quantity of light produced and in the efficiency of the process and at the same time a shortening of life. Decreasing the voltage, of course, has the opposite effect. The laws of variation of candle-power, wattage, resistance, current and efficiency with changes in voltage depend on the filament material. They have been determined with considerable accuracy for tungsten. All these laws may be expressed with sufficient accuracy for most purposes by simple exponential equations. For example, the relation of candle-power to voltage may be expressed by equation (9).

$$(9)\quad \text{C.-P.} = CV^k,$$

where k and C are constants, k being a constant for the filament material and C a constant depending upon the size and normal voltage of the lamp. If candle-power and voltage are taken as the ratio to normal, the equation becomes

$$(10)\ \text{C.-P.} = V^k$$

and there results an equation which may be applied to all sizes and types of lamps having the filament material for whick k was determined.

Similarly, all the other relations may be expressed with equal accuracy. Below is given a table of exponents for the equations connecting several variables for tungsten filament lamps.

Dependent Variable.	Independent Variable.	Symbol for Exponent.	Experimentally Determined Values of Exponent.	Mathematical Relations of Exponents.
Candle-power	Voltage	k	3.66	Taken as fundamental.
Current	,,	t	0.585	Taken as fundamental.
Specific consumption	,,	g	2.075	$g=k-t-l$
Wattage	,,	n	1.585	$n=l+t$
Resistance	,,	q	0.415	$q=l-t$
Specific consumption	Candle-power	f	0.568	$f=g/k$

The relations between all the other combinations of these variables may be directly derived from those given above; in fact, all may be derived from two fundamental relations which involve the three variables, voltage, candle-power and current, as, the first two given in the table.

Fig. 11 shows these relations as obtained experimentally, while the dotted curve is the graph of the experimental equation. It is seen that the agreement is good within the working range of the lamp. The relation may be expressed more accurately by the same equation where the exponent is taken as a variable and a function of the independent variable. The graphs showing the variation of the exponents k and t are shown in Fig. 12. The graphs of all the other exponents may be obtained directly from these as fundamentals.

Changing the voltage brings about another change in the behavior of the lamp. As the voltage is increased the color becomes more nearly that of average daylight, that is, it becomes whiter. So-called color performance curves are shown in Fig. 13. As the voltage is increased the percentages of green and

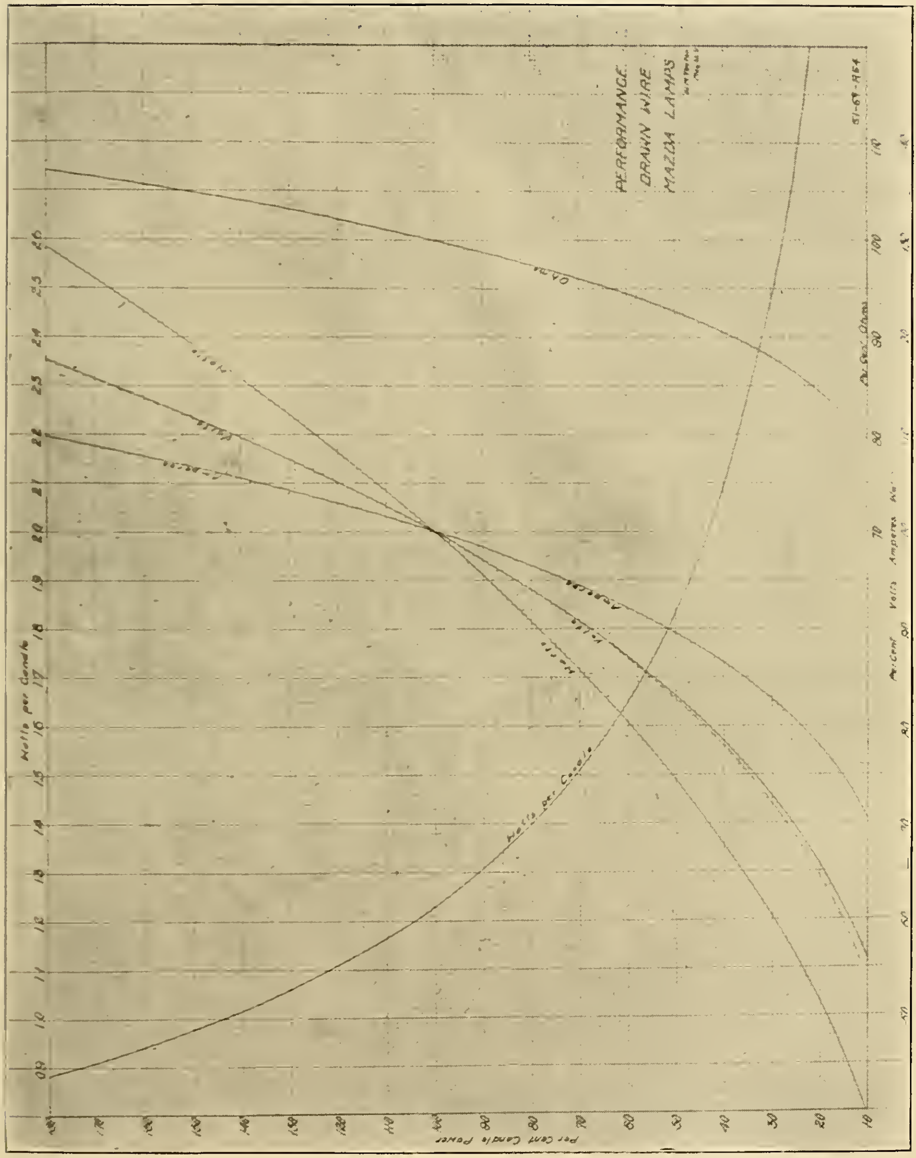
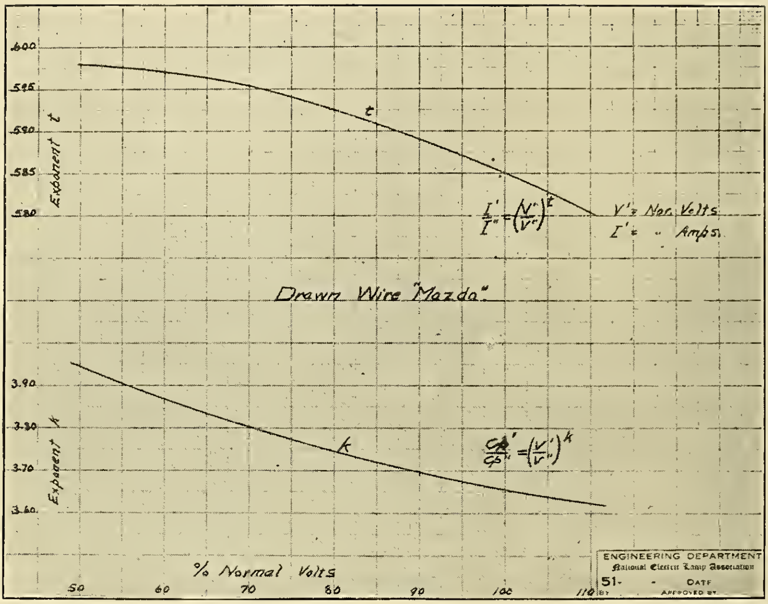

PERFORMANCE
DRAWN WIRE
MAZDA LAMPS
Watts per Candle
Per Cent Candle Power

FIG. 11.



.600
.595
.590
.585
.580
Exponent t
t
V' = Nor. Volts
I' = " Amps.
Drawn Wire "Mazda."
3.90
3.80
3.70
3.60
Exponent k
k
% Normal Volts
50
60
70
80
90
100
110
ENGINEERING DEPARTMENT
National Electric Lamp Association
51-
DATE
APPROVED BY

FIG. 12.

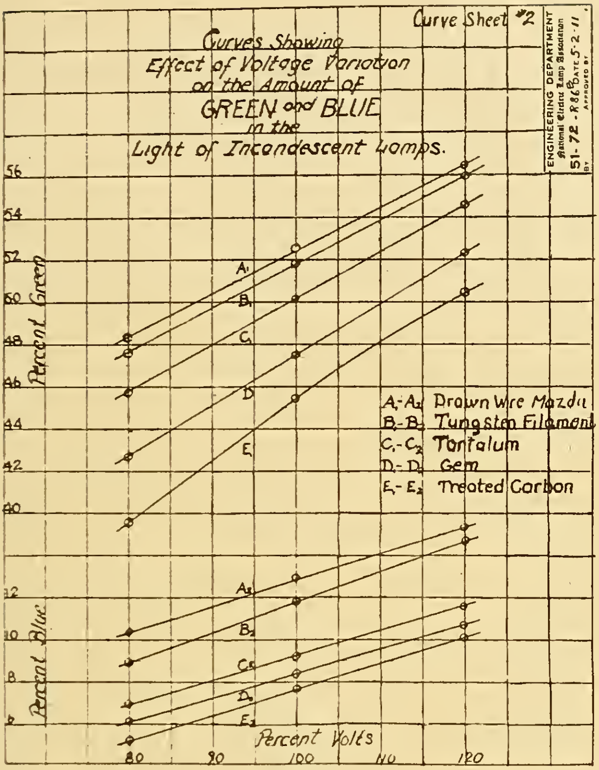


FIG. 13.

blue with respect to red increase. The values given are those as obtained with the Ives Colorimeter, where daylight is taken as 100 per cent. each, — red, green and blue.

After considering the behavior of a lamp when operated at different impressed voltages, the natural question which presents itself for consideration is, What is the best condition for normal operation, all things considered? There are two things in the final result that must be accomplished, — economy of operation and efficacy of service. It may be put in another way. The total cost of lighting should be made a minimum provided that the quality of the light under those conditions is satisfactory.

On the side of low voltage we have a higher energy cost and a lower renewal cost per candle-hour, — also a redder light; and on the side of high voltage a lower energy cost and a higher renewal cost per candle-hour, — also a whiter light. Since the best efficiency as obtained by economy considerations taken for

an average price for energy allows of a color value which is satisfactory for general illumination purposes, the question of efficacy of service takes care of itself in the determination of the best rating for the lamp. A particular case of a very low energy cost might bring a voltage lower than that which would yield a light of satisfactory color.

The rating of a lamp then consists in general of balancing the energy cost against the renewal cost in such a way that the total is a minimum. Obviously such a process depends on the cost of energy, which is a variable, which in turn means that the rating which is best for one condition of energy cost is not best for another condition where the cost of energy is higher or lower. This has brought about the introduction of the three voltage label, where the top voltage is best for users who pay the average price for energy to lighting consumers; the middle voltage is best for those buying energy at a figure considerably below the average retail price; and the low voltage is best for cases of exceptionally low energy costs. The lowest voltage on the label is about the lowest value at which lamps should be operated due to considerations of color of the light and the quantity of light received from a unit of a given size.

It is beyond the scope of this paper to give a complete analysis of the problem of "Best Efficiency," but it might be well to enumerate the various factors which enter into the problem. They are, — variation of efficiency with voltage, variation of life with voltage, variation of candle-power through life, variation of wattage through life, percentage and distribution of the failures which occur before the average life period is reached, and the price of energy.

In order that the operation of a lamp be steady it is necessary that the circuit conditions be constant, that is, the voltage must be constant or if changing cyclically it must do so with sufficient rapidity to give the same effect. A steady, alternating voltage, of course, means one which has a steady effective value. The lamp will, then, perform during a period of one second exactly as it did during the preceding second, but not necessarily at one instant the same as it did at a preceding instant. It is certain that whatever changes do occur through an electrical cycle are repeated in the succeeding ones. It may be of interest to note what happens within the period of one cycle. At any instant of time the filament is receiving energy at a rate determined almost entirely by the voltage at that particular instant regardless of its direction. The energy then is delivered in

"puffs," two per electrical cycle, one for the negative portion of the voltage wave and one for the positive. The rate of energy input is zero twice per electrical cycle and we have two energy cycles per electrical cycle. Fortunately the filament has a capacity for storing energy and the temperature does not fall to the point where the filament gives no light as a result of the rate of energy input falling to zero. The rate of energy outgo (which may be taken as a measure of the light emitted) is, therefore, smoothed out by the thermal capacity of the filament, much in the manner that the torque delivered by a gas engine is smoothed out by the inertia of the fly wheels. The action of the lamp is very well illustrated by the water analog pictured in Fig. 14.* The manner of receiving and discharging the water is analogous to that in which energy is received and discharged by a lamp. The diameter of the cylinder represents the thermal capacity of the filament, the shape of the side slit the law of radiation with temperature and the height of the water the temperature. It will be seen that though the energy be received at rates varying from zero to a high maximum the temperature may change but little. The more rapid the pulsations of input and the greater the thermal capacity of the filament, the smaller will be the variations of temperature.

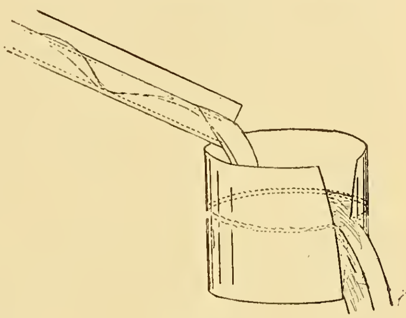


FIG. 14.

Since the temperature must change by at least a small amount, we may conclude that there is a cyclic variation of candle-power for all lamps operated on alternating current. This has been measured for various size lamps and at several frequencies and has been found to be a smooth curve resembling the ordinary sine but displaced from the axis of abscissa. Different conditions of filament size and frequency of operation bring about only a difference in amplitude. Fig. 15 shows curves for three sizes of lamps obtained photometrically † at 25 cycles, and Fig. 16 shows one size, the 25-watt, at three fre-

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* Merrill, Reprint from *Journal of the Franklin Institute*, April, 1911.

† Abstract of these is by Kiely and Wasserboehr, *Electrical World*, February 16, 1911.

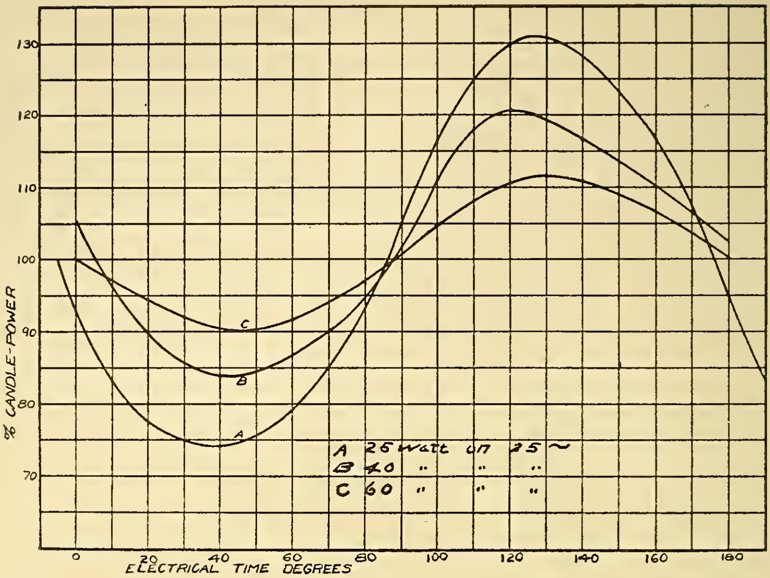

FIG. 15.

quencies. The curves of Fig. 17 show candle-power variation for the 25-watt lamp at 60 cycles obtained by two methods, one photometric and the other a resistant method.* Fig. 18 shows what may be termed the complete instantaneous performance, as calculated from the assumed curve of candle-power variation. It represents about the conditions obtained with a 25-watt lamp on 25 cycles.

It will be noted that there is an angle of lag of about 40 degrees between candle-power and voltage, a fact which is interesting but of no apparent practical value. It is easily calculated because the rate of energy input must equal the rate of energy output both on the crest and in the trough of the candle-power wave. This angle for all practical conditions will lie between 40 and 45 electrical degrees. It is the same sort of a lag as occurs in weather conditions. The hottest part of summer and the coldest part of winter come later than the maximum and minimum inclinations of the sun (which occur about June 22 and December 22, respectively).

The study of the cyclic changes in performance are pertinent to the question in hand because, for satisfactory operation, there must be no perceptible flicker. After having determined

* Edwards and Conner, *Electrical World*, August 19, 1911.

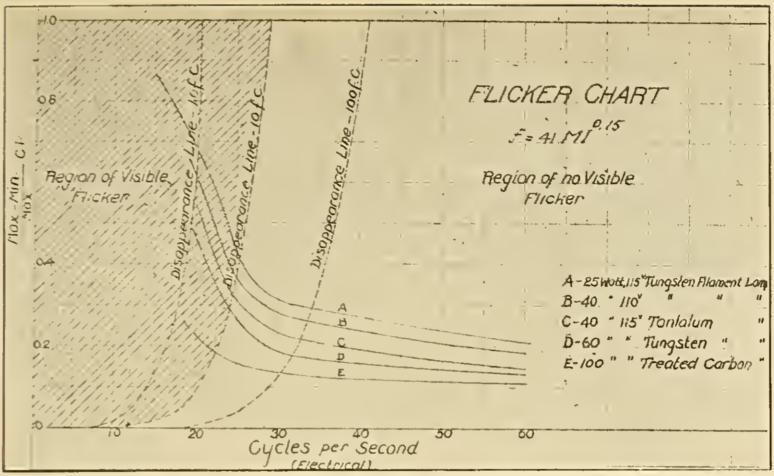

FIG. 19.

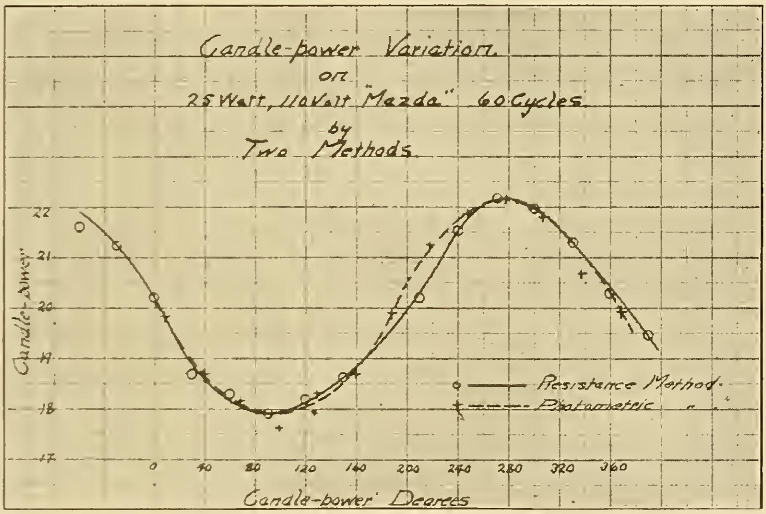

FIG. 17.

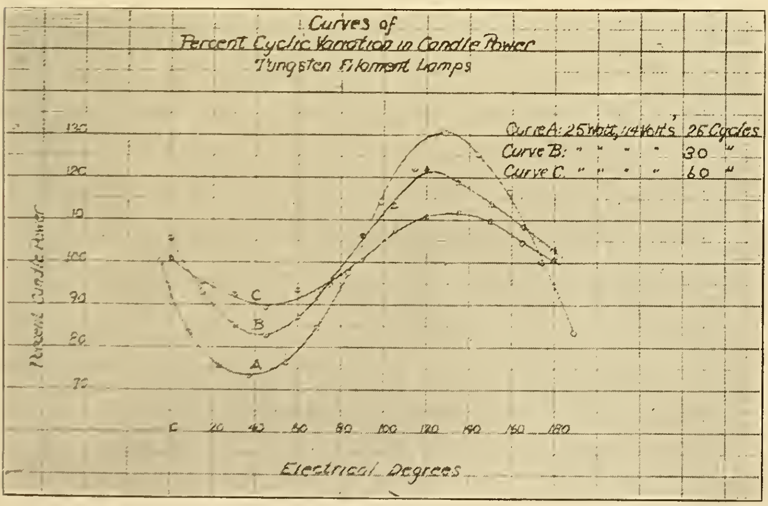

FIG. 16.

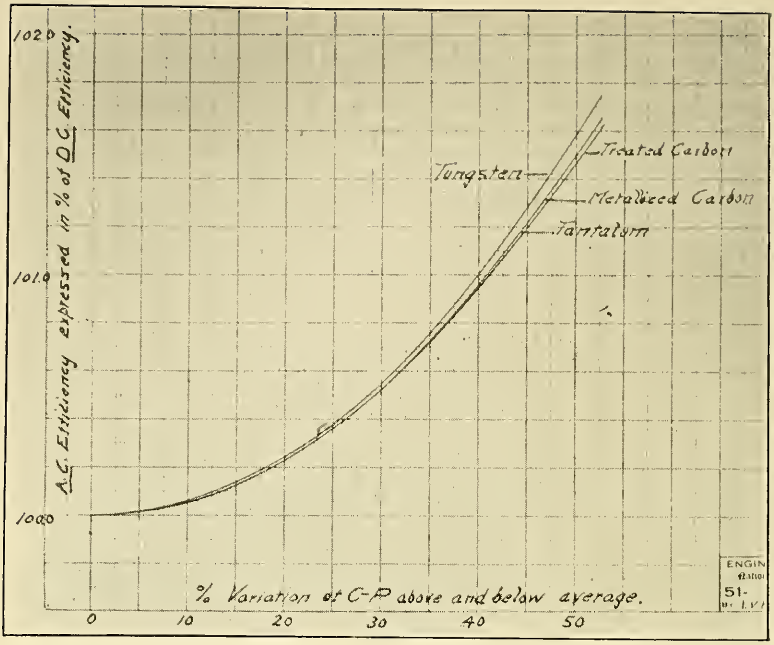
A.C. Efficiency expressed in % of D.C. Efficiency.
102.0
101.0
100.0
Tungsten
Treated Carbon
Metallized Carbon
Tantalum
% Variation of C-P above and below average.
0
10
20
30
40
50

FIG. 20.

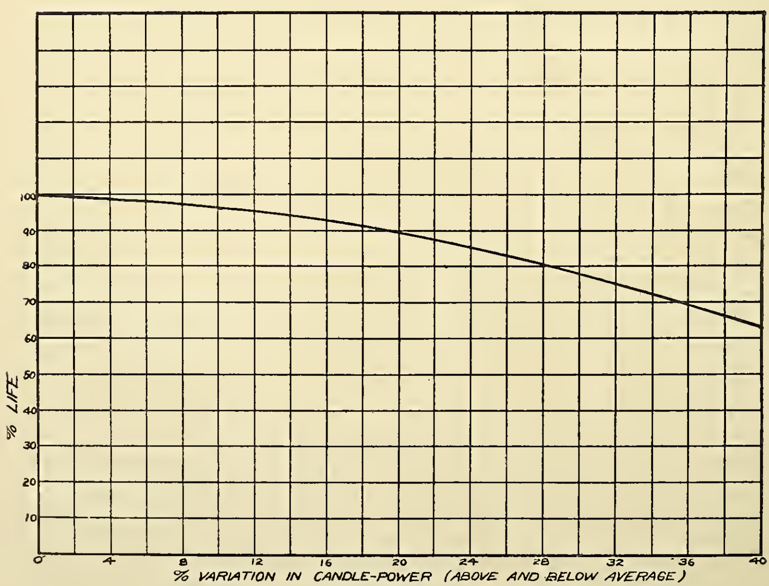
% LIFE
100
90
80
70
60
50
40
30
20
10
0
4
8
12
16
20
24
28
32
36
40
% VARIATION IN CANDLE-POWER (ABOVE AND BELOW AVERAGE)

FIG. 21.

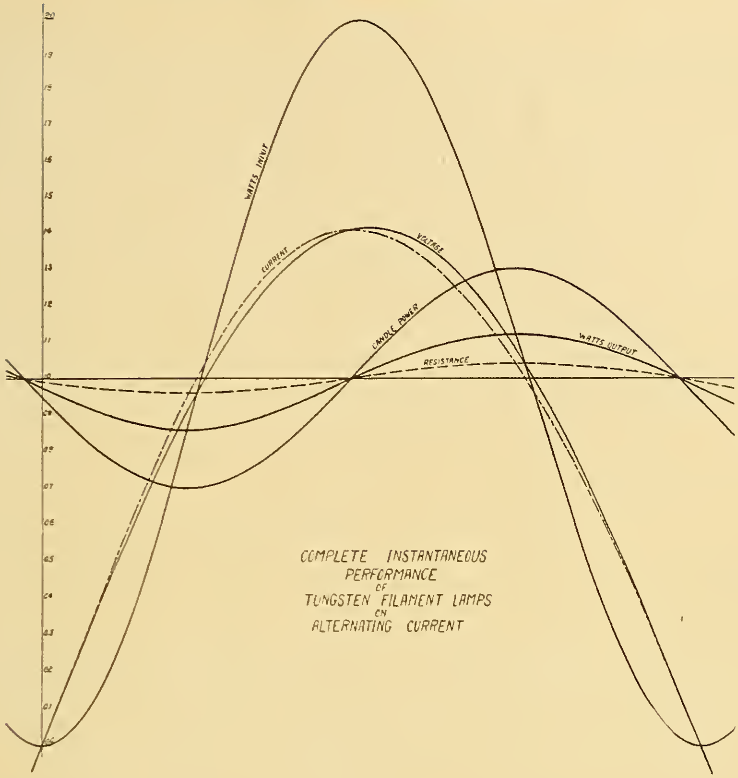

Fig. 18.

the actual cyclic variation in candle-power, it is necessary, in order to find the limits of practical operation, to make a study of the action of the eye. The ability of the eye to detect flicker has been found to depend upon several conditions, the three most important of which are, — range of the cyclic variation of intensity, the frequency of the cycles, and the brightness of the object viewed. The relation is expressed empirically by the equation

$$(11) \quad f = 41(MI)^{0.15}$$

where f is the frequency of light fluctuation at which flicker just disappears, M the limits of variation expressed as the difference between maximum and minimum referred to the maximum, and I is the brightness expressed as the equivalent of foot candles illumination on white paper.

Knowing both the limits of variation of intensity of lamps and the conditions necessary for a disappearance of flicker, it is a simple matter to construct the chart of Fig. 19. First,

curves are plotted showing the candle-power variation with electrical frequency for the various lamps under consideration. It will be seen that every possible condition of operation within the range of frequency shown is represented by some point within the bounds of the diagram. To divide the total area into two parts, one for visible and the other for invisible flicker, it is necessary to assume a constant brightness. Several such divisions corresponding to the three ranges of brightness found in practice are shown. All sizes of lamps are satisfactory at 60 cycles. The 25-watt lamp on 25 cycles will show no flicker for illuminations below ten-foot candles. It should be remembered, however, that the brightness of a reflector or the lamp itself may be very high, so that flicker may be perceptible when viewing the source, when it will not be visible when viewing the objects illuminated.

A lamp operating on alternating current is a trifle more efficient than when operated on direct current of the same voltage. It is too small to measure but has been calculated.* Results are shown in Fig. 20.

There is also an effect on life due to A.C. operation. If the temperature fluctuates, it must be higher than normal part of the time. The shortening of the life due to this excess of temperature is not entirely compensated for by the lower than normal temperature in another part of the cycle. Therefore, a lamp should live longer on direct current than on alternating current, assuming that the same average candle-power is produced in either case. Per cent. of direct current life is plotted against cyclic variation of candle-power in Fig. 21,† which, by the way, was computed. Small effects in life are difficult to find experimentally because of the large number of lamps which must be tested before conclusions may be drawn. Experience has shown that the effect of A.C. operation is small if it exists at all, but beyond that fact there is no experimental confirmation of the curve of Fig. 21.

In concluding it seems proper to enumerate the improvements in incandescent lighting accomplished by the use of the tungsten filament lamp. The most notable, of course, is that of increased efficiency. The new lamp delivers 8 lumens per watt, while the old carbon lamp of a few years ago was able to deliver less than 3, and at the same time gives a longer life and a much better average candle-power. The color value is one more

* Edwards, *Electrical World*, February 16, 1911.

† Beman, Proceedings of Canadian Elec. Asso., June, 1911.

nearly approaching white and one especially well adapted for most illumination purposes. The new lamp can be made for a range of sizes and wattages hardly dreamed of a few years ago, nearly a uniform quality for all. The cost of energy per candle-power hour has been very materially reduced; even the cost of renewals per candle-power hour is less for the larger sizes of tungsten filament than for carbon. The total cost of lighting is reduced more than could have been accomplished with carbon lamps by increasing the thermal efficiency of the generating station to many times its present value. Since a considerable percentage of our national fuel supply is consumed for the purpose of producing light, the tungsten filament lamp is a considerable factor in the conservation of our diminishing supply of coal.

The drawn wire tungsten filament lamp is a better lamp than its predecessor, the so-called "pressed filament" lamp, chiefly because of its greater mechanical strength.

The lamp which is referred to in the subject of this paper is, therefore, efficient, serviceable and adaptable. At least it is if judged by the standards established by its predecessors. But when we contrast the 8 lumens per watt efficiency with the theoretically possible efficiency of 330 lumens per watt for white light, or the 800 lumens per watt for a yellow-green light, or compare the 5 per cent. radiant efficiency with the 100 per cent. of nature's firefly, we are justified in looking for still further improvement, at least in efficiency. The lamp manufacturer has accomplished a good deal, but he does not accept the latest production as the final answer. He is still "on the job," so to speak, and as soon as he learns how to make a better lamp he will proceed to do so.

[NOTE. — Discussion of this paper is invited, to be received by Fred. Brooks, Secretary, 31 Milk Street, Boston, by June 1, 1912, for publication in a subsequent number of the JOURNAL.]

RAILROAD WRECKS.

By D. F. Jurgensen, Member of the Civil Engineers' Society of St. Paul.

[Read before the Society, April 8, 1912.]

I do not know why the committee assigned this particular subject to me, unless it was prompted by the extreme concern caused both to the public and the railroad companies in our state, as well as in the neighboring states, during the past two months, because of the numerous serious accidents which have occurred, and in which many lives were lost.

This subject is a serious and important one to discuss, and early relief must be secured to the public, which is demanding, and is justly entitled to, a safer service, and we, as engineers and builders of railroads, owe it to the community at large to render all aid possible in working out such corrective measures as will, if not entirely, at least materially reduce the number of such accidents and their attendant casualties.

I believe that the number of railroad accidents can be largely decreased without interfering with the present manner of conducting the service.

One would naturally gather from the great advancement made during the past twenty years in the construction of railroad track and bridge details, in the construction of locomotives and cars, and in the development of safety appliances and improved signaling, that the number of train accidents with their attendant loss of life should with all these modern improvements be materially reduced; but that apparently is not the case.

To begin with, it is assumed and granted that no railroad manager, officer or employee, deliberately, maliciously or wilfully conducts his enterprise or performs his duty with a view toward the destruction or maiming of human life.

The railroad manager and officer is without doubt as properly concerned in accidents and wrecks as is the public, because the transportation company is *prima facie* responsible, and often is compelled to pay very dearly for the resulting casualties.

Wrecks are never a good advertisement for a carrier, and, like any other business enterprise which is dependent upon the

confidence and good-will of its patrons for its continued existence and success, railroad corporations can ill afford to ignore or neglect to employ any means, device or agency that may be conducive to the safety of their patrons.

There is probably no industry in existence that is so absolutely dependent upon the human element for its safe operation as is a railway system; for instance, machines have been invented to aid the farmer in economically performing his work by reducing the number of hands that otherwise would be required, but the mind of man has not yet devised a machine that will dispatch and conduct trains, handle train orders, or perform such other duties as now fall to the lot of a general railroad employee.

In this connection it can safely be said without fear of contradiction that in none of the ordinary walks of life are men so well compensated for the services rendered as are, generally speaking, the employees of the American railways; their work is steady, their pay is certain, and their hours of labor and rest have been regulated by legislation to their advantage.

To prevent errors in railroad operation and railroad wrecks, the seat of the trouble or the cause must first be ascertained, and when once found a panacea will be devised. We may here ask, Is the subject of railroad accidents being seriously looked into, investigated and studied with a view towards ascertaining the cause and applying the proper remedy; if so, by whom, and with what success?

It is true that the Interstate Commerce Commission, and many of the state commissions, are now and for some time past have been actively engaged in conducting such investigation. The federal law under which the Interstate Commerce Commission is conducting this work is entitled: "An Act requiring common carriers engaged in interstate and foreign commerce to make a full report of all accidents to the Interstate Commerce Commission and authorizing investigations thereof by said commission."

Said act was approved May 6, 1910. It provides a penalty on failure to make report within thirty days after the end of any month. It also gives the commission power to investigate accidents, and reads in part as follows:

The Commission, or any impartial investigator thereunto authorized by said Commission, shall have authority to investigate such collisions, derailments or other accidents aforesaid, and for that purpose may subpoena witnesses, administer oaths,

take testimony and require the production of books, papers, orders, memoranda, exhibits and other evidence, and shall be provided by said carriers with all reasonable facilities, provided, however, that when such accident is investigated by a Commission of the State in which it occurred the Interstate Commerce Commission shall, if convenient, make any investigation it may have previously determined upon at the same time and in connection with the said State Commission investigation.

Said Commission shall, when it deems it to the public interest, make reports of such investigations, stating the cause of accident, together with such recommendations as it deems proper. Such reports shall be made public in such manner as the Commission deems proper.

Neither said report, nor any report of said investigation, nor any part thereof, shall be admitted as evidence, or used for that purpose, in any suit, or action for damages, growing out of any matter mentioned in said report or investigation.

But the Interstate Commerce Commission, by said Act, is not given any power or authority to enforce the carrier's compliance with any recommendatory measures intended to prevent a recurrence of any such wreck, accident or casualty; i. e., the said federal law goes no further than the mere matter of authorizing investigations, and if the public is to receive any relief from railroad wrecks, it must seek other sources than the Federal Government, as the law now stands in this respect.

The Minnesota Statute, Chapter 122, Laws 1905, gives more power to the State Commission; it is:

An Act requiring railroad companies to report all wrecks and casualties wherein any persons are injured or killed to the Railroad and Warehouse Commission.

Be it enacted by the Legislature of the State of Minnesota.

Section 1. It shall be the duty of every Railroad Company operating a line of railroad in this State to report all accidents, wrecks or casualties occurring in this State to the Railroad and Warehouse Commission. This is intended to include all accidents, wrecks or casualties occurring in the operation of trains or engines on said line or lines of railway within this State, and all other accidents or casualties of whatever nature as may be required under rules adopted by the Commission. *Any reports to the Commission herein required shall not be for public inspection.* All accidents or wrecks occurring in the operation of trains or engines, involving loss of life or personal injury, shall be immediately reported to the Commission by telegraph or telephone message, and the Company shall forthwith send a written report in detail giving full particulars available, in such form as the Commission may require. All other accidents, including accidents resulting in personal injury or death, other than train accidents, shall be reported to the

Commission on the first day of each month covering the preceding month. (As amended, 1907, Chapter 290.)

Sect. 2. Whenever any report is made to the Commission involving a wreck, accident or casualty, and the Commission deems it necessary, *it shall forthwith examine into the causes and circumstances of the same, and it shall thereupon be the duty of the Commission to order such railway company to* comply with any reasonable requirements prescribed by the Commission calculated to prevent the recurrence of any such wreck, accident or casualty, and it shall be the duty of the Commission to report to the Legislature biennially a summarized statement of all wrecks, accidents or casualties reported, together with a recommendation of such additional legislation as it deems proper for the greater protection of passengers and employes of railroad companies. (As amended, 1907, Chapter 290.)

Sect. 3. Every person who shall violate any of the provisions of this act shall be guilty of a misdemeanor and shall be punished by a fine of not less than one hundred (100) dollars, nor more than one thousand (1 000) dollars, or imprisonment in the County Jail for not less than thirty (30) days nor more than one year, or shall suffer both such fine and imprisonment in the discretion of the Court.

Sect. 4. This Act shall take effect and be in force from and after its passage.

(Approved April 7, 1905.)

You will observe that the law is very broad, in that it gives the Commission ample power to go as far as is necessary to obtain results in its investigations. Not only that, the Commission is also given power to order in and to compel the carrier to comply with any reasonable requirements that may be prescribed and calculated to prevent the recurrence of such a wreck, accident or casualty. It is to be noted in this particular that the Minnesota state law goes a step further than the federal Act.

Since the passage of this Act, the Minnesota Commission has unceasingly prosecuted its investigations, and orders embodying corrective measures and has gathered many facts, which are going to be a valuable aid in the final solution of the wreck problem. For a practical demonstration let us use the accidents that have occurred in Minnesota during the year 1911, and carry them through the different stages of classification to a point where conclusions may be arrived at.

Broken Rails.

But before proceeding, I desire at this time to say just a few words on the subject of broken rails.

The public has of late, through the press and other sources, been impressed with the idea that rail failures are one of the *main* agents of railroad disasters. I do not want to be understood here as championing the cause of the steel trust, but in the spirit of honesty and fairness, I believe that the minds of the public should be relieved of that error.

As in the case of the railroad manager, officer and employee, let us be fair in our dealings with the rail manufacturer, and not charge him with having evil design on the lives of the people who are obliged to patronize the carriers, by knowingly and wittingly manufacturing "rotten rails."

The rail manufacturer has been, and is getting, a very good price for his product, and cannot afford for good business reasons, any more than can any other responsible manufacturer, to turn out of his mills anything but the best product. Besides this the manufacturer does not as a rule prescribe the specifications under which the rails are to be made; these requirements are being generally laid down by the carrier or the buyer, who is also privileged to have, and as a rule has, a representative present at the mills, whose duty it is to see to it that the rails are being made in full accordance with the contract. This inspector is given free entry to the works of the manufacturer and is afforded every reasonable facility to satisfy himself that the product is turned out as called for by the specifications.

In this connection there is probably no topic associated with the subject of railroads that has been or is at the present time being subjected to such thorough study, experiment and research as are railroad rails. Several eminent bodies composed of the ablest engineers and metallurgists in this country have been for some time past and are still conducting experiments and tests with a view toward attainment of the ideal rail — and their efforts have already marked considerable progress in that direction.

The Minnesota Commission in considering this subject has recommended that there should be a system of governmental inspection of the construction of cars, rails and all structural iron or steel work used by railroads. In its opinion the increasing number of accidents caused by broken rails and switches, and the imperfect condition of certain portions of equipment, make it very apparent that the interest of both the public and the railway companies will be best subserved by having such inspection.

I will endeavor to demonstrate in a practical way to what

extent broken rails are the cause of railroad wrecks, and in so doing will first refer to the records of the Interstate Commerce Commission, from which it is gathered that in the year ending June 30, 1911, there occurred in the entire United States, 249 derailments which were attributed to broken rails, which accidents resulted in the death of twelve persons, which is less than the average number of trespassers killed on the railways of the United States every day in the year.

The Minnesota Railroad and Warehouse Commission some two years ago interested itself in instituting a systematic inquiry into the matter of broken rails, and to this end required all the principal railway companies operating in the state to report monthly, on forms furnished by the Commission, the broken rails occurring on its lines.

Broken rails directly responsible for wrecks have been brought to the office of the Commission, where chemical analyses and tests were made of the same. The Commission is still prosecuting these examinations, with the result that a large amount of valuable data is being gathered which it is hoped will help in the final solution of the rail question.

To give an idea of the scope of the Commission's investigation, I will quote briefly from the forms used.

> For the purpose of this report, a rail shall be considered broken when complete fracture into two or more parts has taken place, or when there is any break in the head of the rail on gage side, or when there is any break necessitating either immediate removal of rail from track or its reinforcement.
>
> In cases where broken rails have been the direct cause of accidents a special report on Form 55 shall immediately be forwarded to this office, this in addition to the regular monthly report covering same rail.

It is important to know if any useful conclusions can be drawn from these reports. Let us for illustration take the report of Minnesota for the year ending October 31, 1911, and I believe the situation in this state is typical of all the northern states. This particular year is being used because the data have not been compiled for the calendar year of 1911. It is found that on the principal railroads in Minnesota during the year ending October 31, 1911, there were 3 951 broken rails reported. The months of December, January and February are credited with 2 772 breakages, or 70 per cent. of the total for the year. The month of January showed the largest number, viz., 1 645; the month of June had the smallest number, viz., 52. The bulk

of the breakages were of the 85-lb. and 90-lb. sections, including the 90-lb. titanium, and most were rolled at a late date.

Without going into an exhaustive and detailed analysis of the state's investigations, the following inferences may be drawn from its examinations in this connection.

None of the carriers have reported, nor do they claim, that rails have broken, or are breaking, from their own inherent shortcomings, nor does it appear plausible or believable that rails that have safely stood shipment from the mills, handling and placing into track, should fail from their own innate weakness.

The examinations appear to disclose that breakages occur in rails constituted of what may be classed both good and poor quality metal. The failures are undoubtedly largely caused by unusual strains, which are induced by severe and abnormal service conditions to which rails are subjected, in which may be included shocks from broken and flat wheels, defective counter balance, wheels out of round, defective track, improper fastenings of rails upon ties, and other like circumstances which would tend to produce such strains; the investigations disclose that approximately 55 per cent. of the rails broken may be classified as being of good metal, the remaining 45 per cent. of the failures consisting of rails that are of a poor quality metal.

By the term "poor quality metal" is meant rails proving themselves defective after having been subjected to service, covering such defects as the examination indicates, segregation of constituents, unsoundness, brittleness, faulty rolling, including pipe, old seam, flow of metal, split head, crushed head, split web, broken base and other shortcomings, many of which defects it would be impossible to discover at the mill.

It also appears from a careful analysis of this subject recently made by Government experts that transverse fissures develop in the rail section after a rail has been laid and subjected to service, a defect of a most dangerous character, because it cannot be detected except by chance. This defect is said to be caused by heavy wheel pressures which induce internal strain in the steel, which reaches its greatest intensity on the gage side of the head of the rail, where a flow of steel takes place in a lateral direction.

They also find that no foreign substance in the steel is needed to account for the presence of these fissures, and that they invariably occur on the gage side of the rail, and from these and other facts set forth it seems that these fissures are not defects of mill practice and do not exist in a new rail before it is laid.

I desire at this point to quote briefly from the Interstate Commerce Commission's report of the accident on the main line of the Lehigh Valley Road, near Manchester, N. Y., August 25, 1911, which accident was caused by a broken rail, which was a 90-lb. open-hearth rail:

> With the information at present available, it is extremely difficult to suggest any preventive of future accidents of this character. From such information as is at hand, however, it seems apparent that the remedy lies in the diminishing of the wheel pressure and the lowering of direct compressive and bending stresses. The report of our expert clearly shows that exhaustive experiments and tests should be begun, and that a most complete and searching examination should be made of the whole question.

These examinations should deal with steel rails from the furnace and the time they are laid in the track; it should determine whether the tests now used in the steel mills are adequate to detect imperfect rails; it should ascertain whether the use of high carbon steel is not attended with dangers not recognized in the drawing up of current specifications; it should be extensive enough to inquire into the causes which contribute towards such a destruction of the structural integrity of the steel as was the case with this rail; it should take up the securing of measurements in the track of the actual fiber stresses, which are caused by the new types and weights of locomotives, and under different wheels of these locomotives, in order to obtain information from which to judge of the severity of the strains to which the track is daily subjected; in fact, track conditions as they exist at the present time should be dealt with even to the most minute detail.

It also appears that the danger zone in the use of steel rails as at present manufactured has been reached, and since it is supposed that transverse fissures are the direct results of high wheel pressure acting on hard steel, a complete investigation should be made for the purpose of scientifically determining the matter and ascertaining a remedy. Until such an investigation has been made, danger of similar accidents will exist.

Out of the entire year's breakages in Minnesota, viz., 3 951, only four, or one tenth of one per cent. of the breakages caused derailments, as follows:

a. 80-lb. Am. Soc. C. E. Section derailed six freight cars; no casualties resulted. Rail was laid in 1908 on a sharp curve, and had a badly worn ball.

b. 80-lb. Am. Soc. C. E. Section derailed three loaded freight

cars; no casualties resulted. Rail was laid in 1908 on straight track, and was very badly worn.

c. 68-lb. Special Section (of Railway Company) derailed several freight cars; no casualties resulted. Rail was laid in 1891 and was much worn.

d. 56-lb., Section not given, derailed one engine and two coaches of passenger train. No casualties resulted. Rail was laid in 1882, and was much worn.

When it is considered that the four breakages just described were of rails badly worn, one having been in service for twenty-nine years, another for twenty years, it is not at all remarkable that the same should have been broken. It is also to be noted that the four resulting derailments were not the instrument of a single casualty.

From an examination of the rail failures in this state, it is to be observed that broken rails *are not* the cause of railroad casualties to the extent that the public has been led to believe.

It is also found from a study of this question, that as a rule the train responsible for breaking the rail is not always derailed, but that the derailment generally falls to the lot of some following train. This peculiarity may be explained by the fact that a rail is not always broken clear through at first. It may be broken, say, through the ball, or base, and on account of the continual hammering of passing wheels the break is finally carried through the entire section. That there are no more casualties due to broken rails may be explained by the vigilance in policing the track by the track forces of the carriers; the electric track circuit in connection with automatic block signals has also proved itself a valuable broken rail detector.

As the largest number of broken rails occurs during the three winter months, and especially during the periods of extremely cold weather, it appears that railroad travel would be rendered safer if the speed of the heavy passenger trains were restricted within moderate limits during at least the era of extreme temperatures.

On the railroads in Minnesota during the calendar year closed, December 31, 1911, 154 accidents occurred, which may properly be termed railroad wrecks. These are divided into two classes, viz., casualty and non-casualty wrecks. Of the former there were 53, and of the latter 101, which division assigns practically 66 per cent. to the non-casualty, and 34 per cent. to the casualty class. A table is here prepared listing the above described wrecks properly classified under the various causes.

RAILROAD WRECKS IN MINNESOTA, YEAR 1911.

Cause.	Non-Casualty.		Casualty.		Total Wrecks.	Casualties.					
						Employees.		Passengers.		Total.	
	Freight Trains.	Passenger Trains.	Freight Trains.	Passenger Trains.		Injured.	Killed.	Injured.	Killed.	Injured.	Killed.
Broken Rails..	7	..	1	1	9	1	..	20	..	21	..
Broken Switch Points.....	4	..	1	..	5	1	..	..	..	1	..
Collisions.....	12	1	18	7	38	113	8	60	8	173	16
Defective Track......	24	..	2	..	26	2	..	..	..	2	..
Failure of Equipment.	37	3	12	5	57	25	4	22	..	47	4
Failure to Observe Signal	5	1	1	2	9	3	2	6	..	9	2
Open Switch..	4	2	..	1	7	1	..	..	..	1	..
Sun Kink.....	1	..	..	..	1	..	..	..	..	..	..
Track Tampered with..	..	..	..	1	1	2	..	..	..	2	..
Wash-Outs..	..	..	..	1	1	4	4	11	1	15	5
Totals....	94	7	35	18	154	152	18	119	9	271	27

The above accidents for purposes of exemplification are then reclassified into preventable and non-preventable wrecks. Preventable wrecks are those caused by collisions, defective tracks, failure to observe signal, open switches and washouts and which are directly chargeable to human fallibility and false economy on the part of the company. Under non-preventable wrecks are included those caused by broken rails, broken switch points, failure of equipment, sun kinks and track tampered with, the responsibility for which cannot be directly placed. The two final divisions just described, when properly arranged into convenient tabulated form, disclose the following results:

RAILROAD WRECKS IN MINNESOTA, YEAR 1911.

Class.	Number.	Casualties. Number Injured.	Number Killed.
Preventable.........................	81	200	23
Non-Preventable.....................	73	71	4
Total...............................	154	271	27

It follows after the year's data are boiled down into concrete form that the preventable wrecks have resulted the most disastrously to life and limb; also that of all of the five causes in-

corporated under said division, collisions are responsible for by far the greatest number of the killed and injured; i. e., while preventable wrecks produced two hundred injuries and twenty-deaths, collisions were the source of one hundred and seventy-three of the injuries and sixteen of the deaths, which leaves collisions alone accountable for about eighty-five per cent. of all the casualties resulting from preventable wrecks.

Considerable progress has been made in late years by the development of the manual and automatic block signal systems, as measures tending toward preventing collisions. The ideal apparently has not yet been realized thereby, consequently we are led to believe that our investigations in this connection might properly be directed to the question of the possibility of obtaining the advantages assured us by the incorporation of the very best safety systems.

In our discussion toward removing the source of this most disgraceful feature of American railroad practice, we should exclude matters not pertinent to the question, such as comparison of the wreck-resisting qualities of steel and wooden cars, and the policy frequently indulged in by some of the carriers in going to the extreme with record-breaking runs in an effort to outdo their competitors in an attempt to obtain what appears to them to be certain lucrative business.

While the exceptions just cited are far removed from the issue, they may be profitably discussed in their proper place; these discussions, however, will not be of any help in checkmating collisions, and no block system is of any use or value, unless it furnishes ample protection for all trains at whatever speed they may be run.

Of all the classes of railroad wrecks collisions appear to be the least excusable of any. From a study of the rules, regulations and other safeguards thrown around the operation of trains by the carriers, one would wonder how it were possible for a collision ever to occur if strict compliance with rules be rigidly observed; but as previously explained, they do occur, and that with altogether too great regularity, and are the direct source of most of the casualties associated with railroad wrecks.

You ask, Why should this be so? What is the use of drawing up and adopting rules for the purpose of protecting life, and then not complying with them? What is the occasion for the non-observance of rules? The answer is "human fallibility"; and three primary reasons may be given for this ethical weakness, viz., disobedience, negligence and carelessness. Having found

the fundamental causes of preventable wrecks, what is to be done to remove them? The answer is, "Apply disciplinary measures." I desire at this point to quote Mr. Howard Elliott, president of the Northern Pacific Railway Company, in an address before the Minneapolis Publicity Club, a few weeks ago, in which he said in part:

"We hear much about quasi-public corporations, and public opinion has gone a long way in taking away from the owner of public service corporations the right to manage his own property, to name his own rates or prices, to decide about his methods, and has imposed on him the responsibility of providing safe and adequate public service from his private means, but so far has exerted little influence on the men who have to make quasi-public corporations of use to the public. If a man decides to work for a quasi-public corporation, he becomes a quasi-public servant, and he has a moral duty and responsibility to society just as much as the owner has, to see that society is not deprived of the service necessary for its existence.

"The railroad manager is hampered in obtaining absolute precision and reliability. Over many of the employees his authority is divided with the labor unions, which exercise a powerful influence in determining the extent of the authority he is to exercise over their members."

If the conditions claimed by Mr. Elliott pertain to such an extent as to hamper the management of the company in controlling its employees, it is obvious that efficient regulation and supervision by the state can only be secured by going beyond the corporate entity and its executive officers and making each individual employee strictly and personally responsible for the proper and safe performance of his individual duties.

There is a marked contrast in sensibility to duty and responsibility to society between the railway employees of this country and those of European railways. It might be interesting to know that there are less fatalities in connection with the operation of railways in Germany than with the agricultural pursuits of that country.

Whenever a railroad wreck entailing loss of life occurs in that country, all the trainmen and any others who are in any way associated therewith are immediately arrested and held by the state until such a time as they may have exonerated themselves of any blame in connection with the accident, or if found guilty they are punished accordingly by the state. This manner of dealing with the wreck situation undoubtedly has placed Germany and other European countries in the enviable position of having attained the ideal in safe railroad operation.

I firmly believe that when the railroad employees in our country have been made strictly amenable to the state for the faithful attendance to and performance of their duties that an important step will have been taken toward making railroad travel reasonably safe and free from preventable wrecks.

[NOTE. — Discussion of this paper is invited, to be received by Fred. Brooks, Secretary, 31 Milk Street, Boston, by June 1, 1912, for publication in a subsequent number of the JOURNAL.]

A STUDY OF SAND FOR USE IN CEMENT MORTAR AND CONCRETE.

By E. S. Larned, Member Boston Society of Civil Engineers.

[Read before the Society, January 24, 1912.]

Justification for again inviting discussion of this commonplace subject is found in the fact that "general practice" has not shown proper appreciation of its importance; or, if fully alive to it, is disposed, many times, to take chances that frequently lead to distinctly inferior work, and sometimes to disastrous failure. It is, perhaps, more due to failures (than merely inferior work) demanding thorough investigation, that the engineering and, particularly, the architectural professions are coming to give this subject the attention it deserves; and probably the development and enormous expansion in reinforced concrete has had much to do with it, demanding, as it does, for structural and economic reasons, the best grade of concrete possible.

Some idea of the enormous quantity of sand used in construction (cement mortar and concrete only) may be gained by the annual cement production recently reported, seventy-six million barrels, which would require approximately thirty million cubic yards of sand, and this would be greatly increased by the use of sand in plasters and lime mortars. The commercial importance of sand is thus plain; let us consider some of its vagaries as a building material. While nature has been generous in creating sand deposits in most sections of the country, all sections are not equally blessed in the matter of quality, and uniformity is nowhere known except when inferior sand only is found.

How are we to determine the suitability of sand for use in cement construction? By its appearance, rubbing it between the hands to determine its "sharpness" and freedom from dirt and the apparent absence of loam, clay and "other foreign material?" Well, we must admit that this has been a very general practice, but those of us who have had most of it to do have long since refrained from expressing any positive or settled opinion as a result of such examination. Many instances could be cited of sands almost identical in appearance that when tested

would give results 100 per cent. at variance with each other, one being acceptable, and the other entirely unfit for the use intended. In this connection the writer quotes the following passage from his paper on sands given the National Association of Cement Users at Buffalo in the winter of 1907–8:

"The important part sand plays in concrete work is not generally recognized, and even among contractors and engineers who have at some time experienced trouble directly traceable to the sand used, we find a tendency to depend too much at times upon superficial examination.

"One has only to see concrete, of proper proportions and good materials, such as 1 cement to 3 sand and 5 or 6 stone, mixed, to marvel at the wonderful binding qualities of the cement when he observes this mixture at the end of a few days; he will note, however, that the cement must be spread out pretty thin to fill the interstices of the sand and coat the surfaces of the individual grains three times in volume the amount of cement used. If the sand, however, be poor by reason of its geologic origin, mineral composition or decomposition, or because of excessive fineness, or its content of fine material of a non-siliceous nature, then it is useless to expect good results of such proportions as 3 of sand to 1 of cement, and only careful analysis and test of the sand will enable us to judge as to whether it should be used at all, and if so, in what proportions to attain the desired results within the required working limits of seven or twenty-eight days."

The conception and execution of important engineering work necessitate much preliminary investigation and preparation, including a consideration of the available materials of construction; specifications for contract and construction are then prepared, and, in the case of work involving the use of concrete, the proportions are usually explicitly fixed; how often is this done with a prior knowledge of what may be expected in the matter of strength, of the mixtures named, as affected by the use of the local available sand?

The cement is usually most carefully tested under the standard specifications, and the slightest vagaries may lead to its rejection; is it not equally important that the sand used in construction should be subjected to thorough preliminary tests, the results of which might materially affect the proportions to be used, and then carefully watched and tested during construction to maintain its uniformity and improve it if possible?

Sand is added to cement primarily (and almost entirely) for reasons of economy: how can this economy best be obtained

if not by a thorough knowledge of its real net value as a mortar ingredient? Given a strength requirement in mortar of 150 lb. tension at seven days; one sand in proportion of 1 cement to 2 sand just develops this strength; another sand (same locality) in proportion of 1 cement to 3 sand gives equal or greater strength; the saving in cement (per cubic yard of concrete) in the latter mixture is over one third of a barrel. It may be, and some cases could be cited, that some poor sands would, *in time*, produce a sufficiently strong mortar, if properly mixed with the cement, and *having favorable exposure conditions;* but do we know this of the sand in question? Can we afford to wait for the necessary results? Will the structure in the meanwhile be stressed beyond its acquired strength with the probability of injury, serious loss, or even complete failure?

Chemical and mineralogical analyses of sand are seldom called for or necessary and even when made it is difficult, except in extreme cases, to form definite or positive conclusions, as the evidence is often conflicting. Experience suggests that tests and practical results in ordinary sands are affected rather more by their physical condition than by their chemical composition. The granulometric composition of sand, is of course important, but valueless alone, without tensile or compressive tests, and furthermore there is a marked variable in this determintion in the average New England commercial sand obtained from gravel banks, owing to faulty character of the formation, affecting greatly the results of small samples. At present, comparative tensile tests of mortars offer the best indications of the value of sand; a normal cement (or preferably the brand proposed for use) is used with the commercial sand in proportions of 1 cement to 3 sand by weight, the briquettes being of normal consistency as determined by the Standard Cement Specification, and tested at the seven and twenty-eight day periods; the same sample of cement is also tested with the standard laboratory sand (Ottawa) in the same manner, for comparative results.

A sound, clean and well-graded siliceous sand will give as good or better results than the Standard sand, owing to the uniformity in the size of the grain in the Standard. The commercial sand should develop at least 70 per cent. of the strength of the Ottawa sand; this under the Standard requirements for cement necessitates a minimum of 140 lb. tensile strength for the commercial sand at seven days. For practical purposes the comparative tests could be omitted and a limiting tensile strength at seven and twenty-eight days be fixed. However, another and

most important condition lies in the fact that cement mortar in concrete is not of the normal consistency fixed in laboratory practice, and is usually made much wetter, carrying from 40 to 65 per cent. more water. Excess water affects some cements and some sands more than others, and if one wants some approximate idea of how the concrete in construction is to develop, the commercial sand should be tested with excess water and in the same proportions with cement as used in the work; this may show such reduced strength that we shall be led either to condemn the sand, increase the amount of cement, or decrease the amount of water, and the latter could very often be done with much advantage to the work, even though the results appear satisfactory to the casual observer; in fact, an increase in the amount of cement, if still used with an excessive amount of water, will not produce the desired result. Some sands are comparatively soft and weak, or contain an appreciable percentage of coarse particles that are weak; such a sand in the presence of water, a hard gravel or broken stone, when tumbled about in a concrete mixer, will be crushed to dust, and the added fine material may seriously weaken the concrete. Failures of sand in construction are recorded when they had been tested and passed the laboratory normal consistency test; on retest with excess water the trouble was located.

Examination of sand under a strong magnifying glass will give valuable indications of its quality to the trained observer, and some attempt should be made to determine the relative hardness or soundness of the characteristic particles, particularly those of a non-siliceous nature. Coarse sand, well-graded, is superior to fine sand for strength and density; cement improves slowly in fine sand and much greater care and more labor is required to secure a thorough mixture; in many cases fineness is cause for rejection.

Much good would result from occasional inspection of the sand or gravel banks supplying work, to see that the loam or overburden is properly removed, and also observe the formation and consider the possibility of occasional, or even frequent, team or car loads of inferior sand, that might escape detection on the work. If venders of sand were required by the contractors, engineer or architect to submit samples of sand, there would certainly be found a marked choice in the Boston district, at perhaps no greater cost, and then, if they were compelled to keep their deliveries up to the standard of the sample submitted, more uniform and better results would follow. In the case of

defective concrete the burden of proof is usually placed upon the cement, and if the latter has not or does not meet the full requirements of the Standard Specifications, it simply remains for the "cement man" to settle the damage; if the "sand man" knew that he might suffer serious loss upon the delivery and use of poor sand, his interest in good sand would be considerably accelerated.

Table No. 1. Attention is invited to the mechanical analysis and comparative tensile tests of 55 commercial sands, mostly from Massachusetts, for which the writer is indebted to Mr. H. L. Sherman, analytical chemist and cement tester, of 12 Pearl Street, Boston.

Each sample of sand was tested with a known cement for comparison with the Standard Ottawa sand tested at the same time with the same cement, normal consistency being used throughout. Several brands of well-known cements were used, so that comparison of the tensile results should not be made between the commercial sands and only the ratio these sands bear to the Standard sand is comparable. The tabulation is arranged so that the commercial sands (15 in number) showing 100 per cent. (or more) of the strength of Ottawa sand at twenty-eight days appear first, then follow 11 sands that fail to develop 70 per cent. of the strength of Ottawa sand, followed by 29 sands ranging between 70 and 100 per cent.

It is interesting to note that of the 15 samples exceeding the Ottawa sand strength, 14 of these show a higher ratio at twenty-eight days than at seven days; of the rest of the samples it is a coincidence that they appear equally divided in this comparison, 19 of them showing a higher ratio at seven days than at twenty-eight days. If these sands were judged alone on a limiting tensile requirement of 140 lb. at seven days, 6 would be condemned; if they were required to show 70 per cent. of the strength of Ottawa sand at seven days, 12 would be condemned, including one that developed 206 lb. at seven days (exceeding the Standard Specification requirement for cement with Ottawa sand), and another that developed a gain in ratio to 73.8 per cent. at twenty-eight days. Had these sands been tested with excess water, and vigorously mixed to a consistency corresponding to that commonly used in construction (15 to 20 per cent. water by weight) one would expect many of them, testing low with normal consistency, to show results at seven days and even twenty-eight days that would be alarming to constructors in reinforced concrete, and suggest the importance of either using better sand or

TABLE No. 1. — COMPARATIVE PHYSICAL TESTS OF SANDS.

TENSILE STRENGTH.

PROPORTION, 1 CEM. TO 3 SAND.

No.	Character of Sand from	7 dy. Nat. Sand.	7 dy. Stand. Sand.	Ratio, Per Cent.	28 dy. Nat. Sand.	28 dy. Stand. Sand.	Ratio, Per Cent.
1	Bank, Bangor, Me.	342	322	106.2	556	365	152.3
2	Bank, Lowell, Mass.	221	224	98.7	370	299	123.7
3	Bank, E. Mass	293	297	98.6	416	385	108.1
4	Bank, Worcester, Mass	271	259	104.6	372	315	118.1
5	Gravel, Buffalo	310	297	104.4	538	387	139.0
6	River, Grit, Buffalo	262	297	88.2	434	387	112.1
7	Bank, Buffalo	275	297	92.6	530	387	136.6
8	Gravel, Buffalo	373	297	125.6	585	387	151.2
9	Gravel, E. Mass.	265	248	106.9	414	383	108.1
10	Gravel, Maine	418	256	163.3	678	347	195.4
11	Gravel, Maine	419	256	163.7	601	347	173.2
12	Bank, West. Mass.	231	213	108.5	380	324	117.3
13	Stone Dust	386	254	151.9	680	395	172.2
14	Stone Dust, Maine	257	332	77.4	378	361	104.7
15	Bank, West. Mass.	341	282	120.9	423	388	109.0
16	Bank, E. Mass.	140	278	50.4	221	320	69.0
17	Bank, E. Mass.	74	204	36.3	143	277	51.6
18	Bank, E. Mass.	58	208	27.9	80	302	26.5
19	Bank, E. Mass	204	301	67.8	227	346	65.6
20	Bank, E. Mass.	181	268	67.5	228	365	62.5
21	Bank, Nashua, N. H.	164	230	71.3	199	319	62.4
22	Bank, E. Mass.	148	241	61.4	207	332	62.4
23	Bank, Brunswick, Me.	99	206	48.0	140	314	44.6
24	Bank, Maine	135	202	66.8	203	298	68.1
25	Bank, Maine	47	202	23.3	105	298	35.2
26	Bank, Nashua, N. H.	126	230	54.8	149	305	48.9
27	Bank, E. Mass.	197	278	70.9	238	320	74.4
28	Bank, E. Mass.	164	205	80.0	208	277	75.1
29	? New York City	183	216	84.7	274	276	99.3
30	Bank, E. Mass.	172	223	77.1	255	350	72.9
31	Bank, E. Mass.	207	233	88.8	372	437	85.1
32	Bank, Worcester	218	264	82.6	278	385	72.2
33	Bank, E. Mass.	274	301	91.0	285	346	82.4
34	Bank, E. Mass.	206	304	67.8	272	339	80.2
35	Plum Island	220	304	72.4	291	339	85.8
36	Bank, E. Mass.	212	250	84.8	295	406	72.7
37	Bank, Nashua, N. H.	205	250	82.0	293	406	72.2
38	Bank, E. Mass.	261	326	80.1	395	440	89.8
39	Plum Island	256	326	78.5	351	440	79.8
40	Bank, E. Mass.	223	287	77.7	347	411	84.4
41	Bank, E. Mass.	256	297	86.2	345	385	89.6
42	Bank, Maine	304	271	112.2	412	416	99.0
43	Bank, E. Mass.	222	251	88.4	300	317	94.6
44	Bank, E. Mass.	204	262	77.9	287	408	70.3
45	Bank, E. Mass.	217	277	78.3	265	372	71.2
46	Bank, E. Mass.	190	263	72.2	280	397	70.5
47	Bank, Oldtown, Me.	283	311	91.0	331	359	92.2
48	Bank, E. Mass.	179	222	80.6	271	335	80.9
49	Bank, W. Mass.	162	213	76.1	269	324	83.0
50	Bank, E. Mass.	190	254	74.8	374	395	94.7
51	Bank, E. Mass.	204	243	84.0	293	338	86.7
52	Bank, Nashua, N. H.	215	278	77.3	321	455	70.5
53	Bank, E. Mass.	179	293	61.1	237	321	73.8
54	Bank, W. Mass.	201	282	71.2	317	388	81.7
55	Bank, Orleans, Vt.	217	282	77.0	284	388	73.2

TABLE No. 1.—COMPARATIVE PHYSICAL TESTS OF SANDS.

SIEVE TEST — PER CENT. PASSING.

No. 200	No. 100.	No. 50.	No. 30.	No. 20.	No. 16.	No. 10.	No. 8.	No. 6.	No. 4.	¼ in.	No.
											1
1.5	4.0	22.0	35.5	54.0	74.0	82.5	87.5	94.5	99.0	100.0	2
											3
	1.0	6.5	21.0	43.5	62.5	69.5	78.0	82.0	93.0	100.0	4
	1.0	11.5	24.0	36.5	46.5	54.5	61.0	70.0	84.0	100.0	5
	2.0	33.5	50.0	61.0	70.5	77.5	83.0	90.5	97.0	100.0	6
	1.0	16.5	39.0	56.5	69.0	74.5	79.5	84.5	92.0	100.0	7
	0.5	6.5	15.0	31.5	47.5	55.0	62.5	73.5	88.0	100.0	8
	7.5	17.0	26.0	39.0	54.5	65.0	71.0	80.0	93.0	100.0	9
	0.5	4.0	11.0	29.5	54.0	65.5	71.0	81.5	91.0	100.0	10
	1.0	5.5	11.5	22.5	35.5	44.5	52.5	63.0	75.5	100.0	11
	5.0	21.5	39.5	58.5	80.0	89.5	94.5	97.5	99.5	100.0	12
	3.5	9.5	20.5	30.0	49.5	69.5	78.0	85.5	96.0	100.0	13
	19.0	51.7	69.7	79.3	82.7	84.3	85.7	87.3	89.3	91.7	14
	Coarse	sand									15
1.0	2.5	17.5	33.0	50.0	67.5	75.0	82.0	88.5	98.5	100.0	16
											17
											18
4.5	10.0	33.5	50.0	66.0	76.5	81.5	86.0	91.5	97.5	100.0	19
											20
											21
	4.0	30.0	54.0	71.5	82.5	87.5	90.5	93.0	96.5	97.5	22
	1.3	11.5	46.0	77.0	90.0	94.5	97.0	98.0	99.5	100.0	23
	Fine	sand									24
	Coarse	sand									25
											26
											27
											28
											29
											30
											31
											32
											33
											34
											35
											36
	2.0	6.0	11.5	29.0	50.0	60.0	70.0	77.5	90.5	100.0	37
											38
											39
											40
	1.5	14.0	32.5	58.0	73.0	80.5	85.0	89.5	98.5	100.0	41
	1.0	8.5	24.5	52.0	74.0	82.5	90.0	94.5	98.0	100.0	42
											43
											44
											45
											46
	3.5	24.0	47.0	71.5	86.0	93.5	97.0	98.5	100.0		47
											48
	5.0	28.0	57.0	74.5	83.5	87.5	91.0	94.0	98.5	100.0	49
	7.0	27.5	54.5	76.5	89.5	93.5	95.0	97.5	98.5	100.0	50
											51
											52
	0.5	24.0	47.0	65.0	75.5	80.5	84.5	88.0	91.0	97.5	53
	Fine	sand									54
	4.2	24.3	48.0	77.5	92.5	95.5	97.0	98.0	99.1	100.0	55

leaving the forms up for much longer periods than are usually considered necessary.

Much concrete is made entirely too wet, and if in this condition much tamping, spading or forking be done, the coarse aggregate will be driven to the bottom of each layer placed, and a very unequal distribution of cement throughout the mass will follow; laitance on the top of each layer is also developed, destroying the bond of the work to follow. Prolonged mixing with much less water will produce a very soft and mushy mix; concrete of this consistency will not segregate, workmen sink into it above their ankles, but when the foot is withdrawn the hole does not fill with free water; *too much water serves to undo the work of thorough mixing.*

With a view of determining the variability of wet mixtures, the writer made the following test in 1906.

Gang molds were placed vertically over each other, eight in all, to contain a layer 8 in. deep; the joints between molds were sealed with a thin layer of a mixture of white wax and tallow to prevent the escape of water. A high-grade Pennsylvania Portland cement was used in the proportion of 1 part cement to 3 parts of Standard Ottawa sand, by weight, gaged with 20 per cent. water. Fine annealed wire (32 gage) was inserted between consecutive molds, and when the mixture had partially set these wires were used to cut the gang molds apart, and the operation was satisfactory in producing perfectly formed briquettes. The briquettes were then allowed to remain in the molds over night, under a damp cloth, and were then removed and immersed in water until broken.

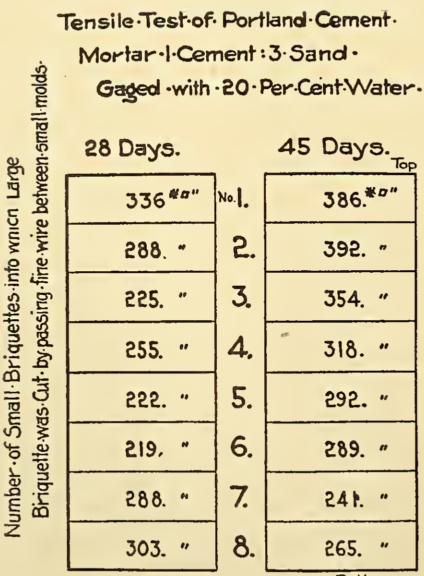

Fig. 1.

The consistency of this mortar compared closely with that of much of the wet concrete now used, drier than some I have seen used in large work. When the molds were filled the mixture

was churned and worked with a glass rod about one-quarter inch in diameter. The following results (Fig. 1) are the average of three briquettes, a total of 48 being in the series; No. 1 briquette is from the top layer and No. 8 from the bottom.

The purpose of this experiment would have been accomplished in the test for one period alone, but it was deemed inexpedient to make the trial for any time short of one month. The inferiority of the briquettes in the bottom layers is clearly apparent, there being a maximum loss in strength of 117 lb. at twenty-eight days and 151 lb. at forty-five days. It would appear entirely reasonable to assume that a greater variation will be found in a seven-day test than in either of the above two noted.

FIG. 2.

TEST TO DETERMINE EFFECT ON TENSILE STRENGTH OF PORTLAND CEMENT MORTAR 2:1 USING DIFFERENT PERCENTAGES OF WATER IN GAGING.

Table No. 2 and the diagram Fig. 2 are also given, showing the tensile strength of Portland cement mortar mixed in the proportion of 1 cement to 2 sand and gaged with different percentages of water, ranging from 8 per cent. to 20 per cent. Sand known locally as " Plum Island " sand was used with high-grade cement. The results given are the average of three briquettes. Percentage of water used was determined on the combined weight of cement and sand. Briquettes were immersed in water until broken after remaining twenty-four hours in a moist air closet. The injurious effect of using too little water is plainly evident in the 8 per cent. series and requires no further emphasis. Up to six months the superiority of the drier mixtures, excluding the 8 per cent. series, is quite uniform, and it would appear that from 12 to 15 per cent. water would give the best results in a mortar of this composition, namely, 1 cement to 2 sand. Fourteen per cent. water will yield a very plastic mortar if properly tempered.

TABLE No. 2.

Portland Cement Mortar, 1 Cement to 2 Sand.

Tensile Strength, Pounds per Square Inch.

Water, per cent.	8	12	14	16	18	20
Time of Test.						
7 days	261	433	392	368	338	301
28 days	344	470	447	436	422	407
3 months	344	490	494	491	457	454
6 months	392	543	536	497	472	430
12 months	300	463	478	434	446	474

While this test also shows a very good recovery in the wetter mixtures (18 and 20 per cent. water) at twenty-eight days, it must be kept in mind that Plum Island sand is very clean and contains practically no very fine material to affect and retard the strength; there was also practically no opportunity for segregation owing to the size of the briquettes and method of molding.

Table No. 3 is added showing the tensile strength of cement mortars in the proportion of 1 part sand to 1 of cement, by weight, for Rosendale or natural cements, and 2 parts sand to 1 cement for the Portland. A siliceous sand was selected for this test, carefully screened to the sizes noted, and combined in the proportions given in the table. The test was made to determine the relative value of sand grains of different diameters, in combination with cement, and also to study the effect upon the tensile results of adding fine material.

Few unwashed natural sands are free from dust, of a loamy or clayey nature, containing organic material, and in specifications calling for sand clean and sharp and free from fine material the importance of excluding this deleterious agent is recognized, but it is not always possible to enforce this exclusion absolutely; and from mechanical analyses of a large number of samples, and casual inspection of sand in use at various points, I am satisfied that much sand is used that contains 5 per cent. of dust, and a good deal that carries as much as 10 per cent., and even more in some instances.

The fine material passing the 100-mesh screen used in this test was obtained from a clean, white, siliceous sand; and if, with increasing amounts of this material, a falling off in tensile results appears, it can in no sense be taken as a measure of what would follow by using sand containing a dust of loamy or clayey nature.

Explanation of the results is hardly required; it will be noticed, particularly in the case of the natural cements, how uniform and constant is the falling off in strength at the seven-

TABLE No. 3. — Tensile Strength of Cement Mortar with Sand Grains of Different Diameters.

Results given are the average of six briquettes.

Sand Gage Per Cent. Used.				Natural Cement Mortar, 1 : 1.								Portland Mortar, 1 : 2.			
				Water, Per Cent.	"Union."			Water, Per Cent.	"Hoffman."			Water, Per Cent.	"Giant."		
No. 30.	No. 20.	No. 100.	Fine.		7 days.	28 days.	6 mos.		7 days.	28 days.	6 mos.		7 days.	28 days.	6 mos.
100	..	..	..	17	156	193	352	15	115	163	314	10½	286	288	412
..	100	..	..	17	151	194	349	15	118	146	286	10½	294	331	473
..	..	100	..	17	153	187	340	15	91	110	257	10½	201	226	294
..	..	..	100	17	100	123	307	15	71	76	186	10½	129	159	223
80	10	10	..	17	154	210	358	15	94	124	301	10½	361	380	486
70	15	12½	2½	17	142	190	332	15	86	107	254	10½	301	303	428
60	20	15	5	17	143	192	342	15	83	107	285	10½	307	311	419
50	25	17½	7½	17	140	208	345	15	80	89	291	10½	391	400	538
40	30	20	10	17	133	197	362	15	90	82	296	10½	350	355	475
30	25	30	15	17	123	191	329	15	78	77	266	10½	362	359	478
20	20	40	20	17	128	199	318	15	66	73	285	10½	317	374	480
10	15	50	25	17	122	201	324	15	68	72	221	10½	291	354	488
50	..	..	50	17	108	193	317	15	62	70	239	10½	247	287	351
50	50	..	..	17	154	222	323	15	82	107	316	10½	440	408	542
50	..	50	..	17	150	210	344	15	78	88	290	10½	309	336	438
25	25	25	25	17	125	183	302	15	74	68	250	10½	279	337	447
	Crushed	quartz													
40	..	60	..	16	179	256	3 mos. 355	14	93	100	3 mos. 142	9½	257	331	3 mos 351

Memoranda. — All proportions and percentages determined by weight. Natural sand used, first passed through No. 8 screen and residue excluded. No. 30 sand passed No. 20 screen and caught on No. 30 screen. No. 20 sand passed No. 8 screen and caught on No. 20 screen. No. 100 sand passed No. 30 screen and caught on No. 100 screen. "Fine" is clean white sand sifted through the No. 100 screen.

day period as the amount of fine material increased. This tendency, in the case of Union cement, disappears at the twenty-eight day period, at which time rather remarkable uniformity is found in all the combinations, except the 100 per cent. fine; serious retardation in the improvement of the Hoffman, with the increase of fine material in the sand, is noticed between the seven-day and twenty-eight-day periods, the mixtures containing over

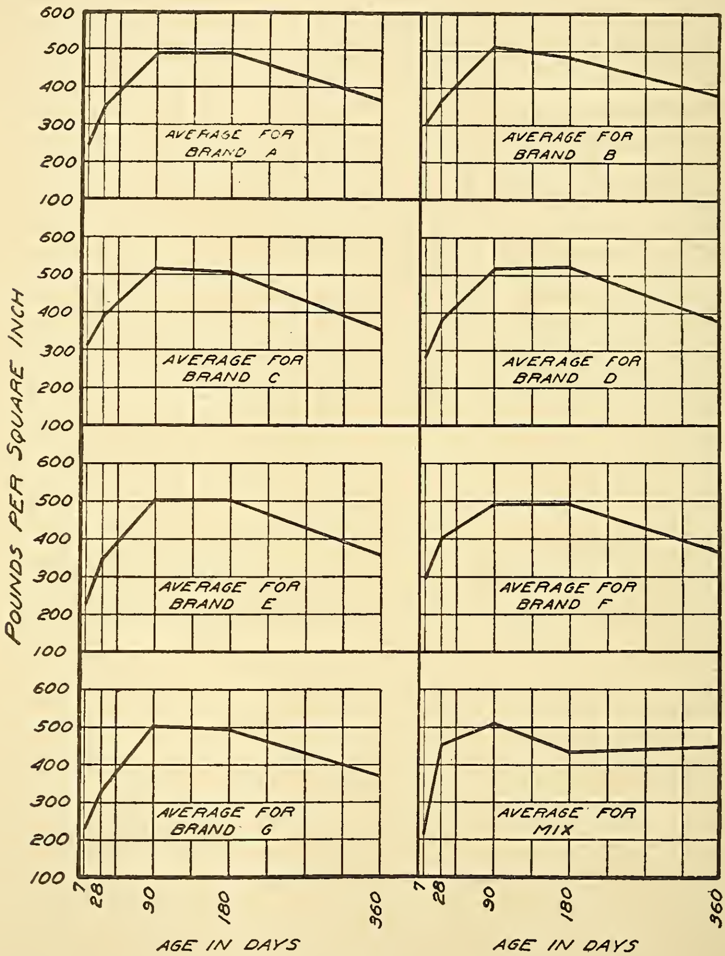

Fig. 3.

Curves showing Variation of TENSILE Strength with Age of 1:3 Standard Sand Mortar.

From Bulletin 331, U. S. Geol. Survey, Portland Cement Mortars and Their Constituent Materials, by Richard L. Humphrey and William Jordan, Jr.

5 per cent. fine remaining almost latent for this time, three of the combinations showing an actual loss, while four make a small gain, the average gain being 2 lb.; a rapid recovery is found, however, in these combinations between the twenty-eight-day and six-months periods, and it is to be regretted that longer time tests were not made.

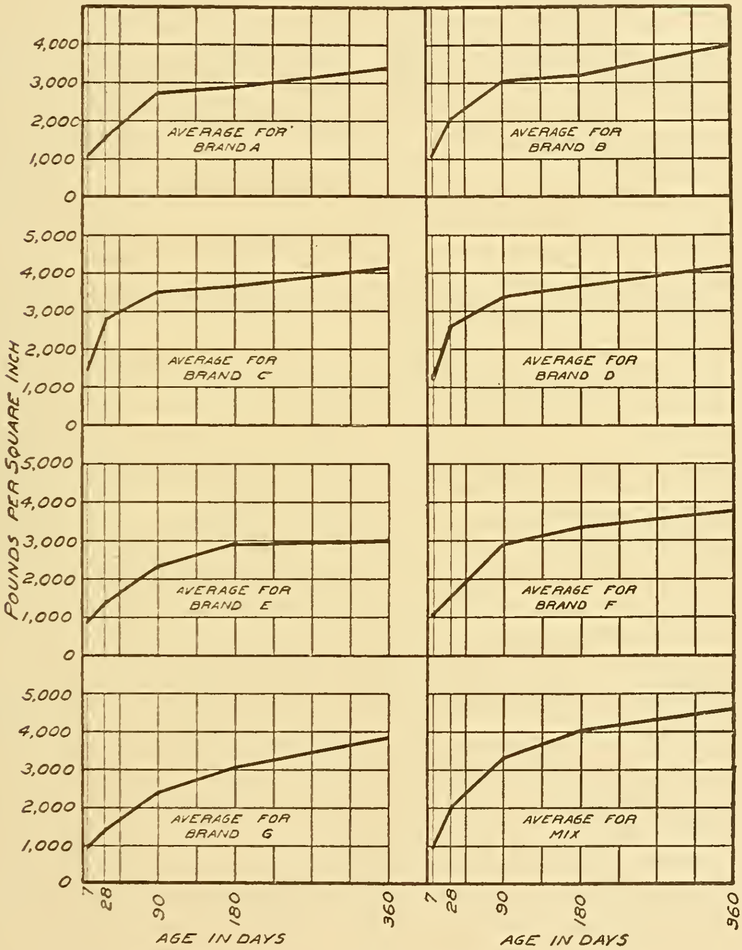

FIG. 4.

CURVES SHOWING VARIATION OF COMPRESSIVE STRENGTH WITH AGE OF 1:3 STANDARD SAND MORTAR.

From Bulletin 331, U. S. Geol. Survey, Portland Cement Mortars and Their Constituent Materials, by Richard L. Humphrey and William Jordan, Jr.

A tabulation of the results, excluding the series in which all fine and crushed quartz were used, is herewith given:

	Seven Days.			Twenty-Eight Days.			Six Months.		
	Aver.	Max.	Min.	Aver.	Max.	Min.	Aver.	Max.	Min.
Hoffman.....	84	118	62	99	163	70	277	316	221
Union.......	139	156	108	198	222	183	336	362	302

The effect of the fine material upon the Portland cement is not so noticeable, even at the shortest period, except in the series with 100 per cent. and 50 per cent. fine, and no parallel can be drawn between the test with Portland cement and the results with Rosendale cement, using the same combinations of sand.

Mica present in sand in quantity as low as two per cent. seriously affects its strength. Clay matter is usually detrimental and its presence sometimes is difficult to detect. Decomposed feldspar has been found to greatly weaken sand mortars and its presence should always be viewed with suspicion. Organic material, in very small quantity, may cause an apparently good sand to be worthless in mortar.

The relation of tensile to compressive strength of mortars is of interest, and diagrams numbered 3 and 4 are added to show this; they are taken from "Portland Cement Mortars and Their Constituent Materials," by Richard L. Humphrey and Wm. Jordan, Jr., published in Bulletin No. 331 of the United States Geological Survey. The tests were made in mortars of 1:3 composition, using specially selected samples of cement and Ottawa sand, and maintaining normal consistency throughout. The ratio of compressive strength to tensile strength is not constant for all periods of time or for different mixtures.

With a view of showing the important effect of additions of sand upon the tensile strength of cement mortar, the following tabulation has been interpolated from the diagram of cement mortar tests prepared by Mr. W. Purves Taylor, of the Philadelphia Municipal Laboratories.

The results of the neat tests and the 1:3 mortar tests (i. e., one part cement to three parts crushed quartz by weight) are averaged from over 100 000 tests, while the other results are based on from 300 to 500 tests:

TENSILE STRENGTH IN LB. PER SQ. IN. OF PORTLAND CEMENT.

Proportions.	7 Days.	28 Days.	2 Mos.	3 Mos.	4 Mos.	6 Mos.	12 Mos.
Neat Cement.......	710	768	760	740	732	758	768
1:1 mortar.........	590	692	690	680	680	685	695
1:2 mortar.........	370	458	460	455	453	458	460
1:3 mortar.........	208	300	310	310	310	310	308
1:4 mortar.........	130	210	230	230	230	232	232
1:5 mortar.........	80	150	185	195	195	195	197

It must also be kept in mind that these results are obtained under practically uniform and theoretically correct conditions, in the amount of water used, thoroughness of mixing and molding and storage of samples until tested.

In closing, the writer desires to quote again in part from his paper on "Sands" given the National Association of Cement Users in 1907:

"The general tendency in reinforced concrete construction, in the best practice, is toward richer mixtures, particularly for columns, beams and girders. The economy and logic of this is readily seen:

"1. It makes possible the more economic handling of forms.

"2. It is a safeguard against the dangers of average poor sand.

"3. It means added strength and insures closer and more perfect contact with the steel.

"4. It reduces to a minimum the personal equation in mixing and placing the concrete, the latter operation sometimes called 'unmixing.'

"5. It means better fireproofing in that the aggregate and steel are better covered and protected.

"6. It is denser, stronger and more waterproof.

"7. The difference in cost per cubic yard of concrete is nominal and much less than appears by reason of the advantages under Nos. 1 to 6."

The actual difference in cost of cement alone, per cubic yard of concrete, is given below, the assumed cost of cement being $1.25 per barrel net.

Proportions.	Cement Required. Bbls.	Cost Cement per Cubic Yard.
1: 1½: 3	1.90	$2.38
1: 2: 4	1.48	1.85
1: 2½: 4	1.38	1.73
1: 3: 5	1.14	1.43
1: 3: 6	1.02	1.28

If reinforced concrete in building construction could be figured at *as low an average cost as $20* per cubic yard, the per-

centage cost of cement would be as follows for the several proportions given:

Proportion.	Cost of Cement — Percentage of Total.
1 : $1\frac{1}{2}$: 3	11.9
1 : 2 : 4	9.3
1 : $2\frac{1}{2}$: 4	8.7
1 : 3 : 5	7.2
1 : 3 : 6	6.4

Standard Specifications for commercial sand, with uniform methods of testing, would be of great benefit to the professions, but until that can be effected the engineer will have to consider his own requirements with due regard to the materials available.

DISCUSSION.

PROF. F. B. SANBORN. — Whenever I hear a paper similar to this, by a person like Mr. Larned, who has made a special study of either the cement or the sand question, — and they are of course, closely related, — I usually ask myself: "What are the various sources of sand supplies here near Boston?" I want to ask Mr. Larned now if there has been any survey of sand pits and sand supplies, any such survey made in the way that many surveys are in the Middle States, of water supplies, agricultural phosphates, pottery clays and so on. I do not know that I have heard of sand surveys being made except in a small way. I had two students last year who took for a thesis subject the investigation of sand supplies in the city of Medford. They tried to locate the pits and to give some idea of their capacities and then make tests of the sand and tabulate the results. They also indicated what the sand might be used for and its commercial possibilities. My question to Mr. Larned then is, To what extent have such surveys been carried out on a larger scale?

MR. LARNED. — I do not know of any such survey having been made, but would regard an intelligent study of this matter, with full information as to the location of sand pits, quantity available, facilities for shipment, delivery and quality of materials, as a most valuable aid to the profession.

MR. H. F. BRYANT. — I would like to ask Mr. Larned if I correctly understand the curves as showing that, at the end of a year, mixtures with 20 per cent. of water were increasing in strength while other mixtures were decreasing, and whether these results are continuous.

Mr. Larned. — The curve and tabulation referred to, showing tests of Plum Island sand with water from 8 per cent. to 20 per cent., do show a very good recovery in tensile strength, in the case of the 20 per cent. water for seven days, and from then on to twelve months. It must be borne in mind that these results, based on briquettes made with a perfectly clean sand, are not to be confused with field results, in which a different quality of sand, — one perhaps containing non-siliceous fine material, — may be used. In a specimen of this size, made under laboratory conditions, there is not the same opportunity for segregation of materials occasioned by the excess water that would follow in mass work.

The fact that some of the intermediate consistency briquettes show retrogression in tensile results at twelve months is not an indication of inferiority, since the wetter mixtures would undoubtedly show the same tendency if carried through for longer periods.

Tests for compression do not show this retrogression, so far as I am informed, at any period of time; since, however, permeability is a measure of density and density a measure of strength, it is to be expected that excess water mixtures would not finally show so good results as a mixture resulting in the greatest density.

That tensile results show retrogression is explained by the fact that, as the briquettes become more brittle with age, they are affected by eccentric loading, owing to the short section of the specimen, and are affected by a combination of shear and tensile stresses.

Mr. E. P. Adams. — I would like to ask Mr. Larned if he knows of a consideration of sands for building purposes in which the mechanical analysis of the sand has been considered, that is, definite proportions of sand of various sizes, to determine what is the best proportion of the particles of the sand to get the results showing the most strength in the concrete.

Mr. Larned. — This is a frequent determination. It was made in connection with the construction of a notable standpipe in this district. Void determinations were made in the case of the sand and stone, and the cement and sand were proportioned to give the greatest density. It was found, after some time, that an average of the results obtained were so close to a 1:2:4 mix with the materials there in use, that they cut out the laboratory expense and followed this conventional mixture. The attempt to grade sand on the basis of its granulometric

composition is a frequent one, but few sand pits run at all uniform, and the method of obtaining the sand and making the mixtures in a practical commercial way can hardly be expected to give results concordant with laboratory determinations, based on small samples. The sand formation is broken up and faulty, and the resultant mixtures would be subject to great variation.

MR. ADAMS. — I did not intend to ask the question as Mr. Larned understood it. What I was talking about was not the proportion of sand in the aggregate, but the proportion of the particles in the sand itself.

I believe that sand which has both coarse and fine particles really produces the best results; but, as to just what the proportion of large and small particles should be, I do not know. My inquiry was not what would be the best mixture of stone, cement and sand, but what would be the best sand.

MR. LARNED. — The best sand can only be determined as a result of tensile or compressive tests of mortars. It has been established that in the case of a clean, sound, siliceous sand, well graded to the point of minimum voids, you will get better results, if the correct proportion of cement be used, than with a similar sand, not graded, and in consequence showing a higher percentage of voids. In the case of commercial sands, however, differing in origin and physical characteristics, and percentage of voids, this rule cannot be depended upon. An example may be cited of a sand that gave very poor results, and it was suspected that this was occasioned by its inferior granulometric composition. A synthetic mixture was made of pure siliceous materials, to correspond in grading with the sand in question, and giving high results this suspicion was disproved, and the results given in Table No. 1 show comparative tests on 55 different sands indicating that the best results are more dependent upon the physical characteristics of the sand and of the fine content, if any, than upon the grading of the sand. The effect of grading, in which it was attempted to show the best combination obtainable, is shown in Table No. 3, but it will be observed that this is also affected by the physical characteristics of the cements used.

I might tell you something that has come up within the past two weeks that is of interest: My experience has always led me to believe that an inferior sand can be expected to retard the setting properties of a normal cement, but I have actually had submitted to me a sample of inferior sand which caused a normal cement to be quick setting. Thinking it might be chemical in action, I took a large sample of this natural sand, and by

careful washing recovered a large quantity of fine material, amounting to $2\frac{1}{2}$ per cent. by weight of the sand under investigation. With the idea that this was the injurious material in the sand, I mixed it with Standard Ottawa sand in the same proportions in which it was found in the commercial sand, and made the following tests: A Standard Normal Portland cement with Ottawa sand and tap water; the same cement with Standard sand and the dirty water resulting from washing the commercial sand; the same cement with Standard sand and $2\frac{1}{2}$ per cent. of the fine material added, mixed with tap water; and the same cement with Standard sand with $2\frac{1}{2}$ per cent. of the fine material added, mixed with the dirty water. The results were negative, all showing tensile results at seven days above 200 lb., and the greatest difference between the maximum and minimum results amounting to only 21 lb. None of the combinations showed any indication of quick set. The commercial sand, unwashed, in the same proportions gave practically no strength at seven days, and showed quick set with a Portland cement having normal setting properties.

[NOTE. — Further discussion of this paper is invited, to be received by Fred. Brooks, Secretary, 31 Milk Street, Boston, by June 1, 1912, for publication in a subsequent number of the JOURNAL.]

OBITUARY.

William Stuart Henry.

MEMBER ENGINEERS' CLUB OF ST. LOUIS.

WILLIAM STUART HENRY was born in Natchez, Miss., April 22, 1864. In 1865 his parents moved to St. Louis.

He was graduated as a Bachelor of Engineering at Washington University of St. Louis in the class of 1886.

Mr. Henry began his engineering career with the St. Louis Water Department, serving as draughtsman during 1886 and 1887 and as assistant engineer on construction of the Water Works extension at the Chain of Rocks until 1892.

In 1893 he organized the Metalstone Construction Company, of which he became vice-president and manager, continuing in this capacity until 1895.

In 1896 he became associated with the Myers Construction Company, doing a general contracting business, as vice-president and engineer in charge of construction, which position he filled at the time of his death.

He became a member of the Engineers' Club, February 15, 1905. He was also a member of the American Society of Engineering Contractors.

Mr. Henry was married at St. Louis, February 13, 1888, to Miss Adeline Theobald, who with three daughters survives him.

The writer's acquaintance with Will Henry began in the year 1881, when as students they attended Smith Academy. This acquaintance resulted in a close friendship continuing to his death, at which time they were associated together in business.

As a student, Henry applied himself to his work with characteristic energy and persistence, showing little inclination to participate in the usual student diversions, either in or out of study hours.

Being naturally reticent and non-communicative, he did not acquire new friends and acquaintances readily, but to know him well was certain to make one his friend. To those who did not understand him and his outspoken frankness, he sometimes gave the impression of a lack of consideration for others, but his manner was but the expression of the man's inherent candor and honesty.

Mr. Henry's death occurred at his residence in this city, January 27, 1912, after a lingering illness of four months, through all of which he displayed remarkable patience and fortitude, finally passing away quietly and without apparent pain.

ASSOCIATION OF ENGINEERING SOCIETIES.

Organized 1881.

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CENTRIFUGAL PUMPING PLANTS FOR IRRIGATION AND DRAINAGE.

BY H. L. HUTSON, MEMBER OF THE LOUISIANA ENGINEERING SOCIETY.

[Read before the Society, October 9, 1911.]

IT is not the intention to make this paper as broad as its title might indicate, but to confine it strictly to plants of moderately large capacity such as are used by the irrigation canal companies of Louisiana and Texas for raising water from rivers into their canal system and to plants used for draining lands for agricultural purposes along the Mississippi River and the coast lands of Louisiana. The smaller plants, such as are used by private individuals for pumping from streams or wells, would make a very interesting study, but are outside the range of this paper. Also sewerage pumping and the systems for city drainage are excluded, as the problems are altogether different from that of draining lands for agricultural purposes.

Centrifugal pumps have been used for raising water for irrigation long enough for the practice in designing these plants to be practically standardized. This applies particularly to the rice irrigating canals as this industry has existed for twelve or fifteen years. The practice in the Rio Grande Valley, where water is used for irrigating other crops, and where the pumping season lasts throughout the year, has not yet reached a settled basis, and there are very cheap uneconomical plants alongside plants of the highest class. In drainage work, both practice and engineering opinion vary widely, and no one can judge at this time what will be the final outcome in regard to the type of

equipment to be used. In this paper I will describe, first, the type of machinery used in the irrigation plants, and then give what, in my opinion, will be the modifications necessary to adapt the same type of equipment for drainage work.

Irrigation.

It will be well first to consider the service which these irrigation plants have to perform and then review rapidly the history of the rice industry, as in this way a better idea can be given of the development of the large pumping plants. For raising rice, it is necessary to furnish water sufficient to keep the crop flooded from the time the young plant appears above ground until it is headed out and the grain is ready to ripen, at which time the water is drained off in order to allow the fields to dry out sufficiently for harvesting. This means that pumping must be carried on for about three months in sufficient quantity to keep all of the acreage needing water flooded. In other words, we must pump on to the land enough water to make up for seepage, evaporation and water which the growing crop drinks up and gives out to the atmosphere through its leaves. In the prairie lands of Louisiana and Texas, where there is a stiff clay subsoil, the seepage must be almost negligible, and in this territory it is customary to figure that a pumping plant capacity in gallons per minute equal to $7\frac{1}{2}$ gal. per acre is sufficient to water the crop. These plants operate twenty-four hours a day, and are often run above their rated capacity when the weather conditions are unfavorable. A crop of rice requires about 30 in. of water, some of which, of course, may be supplied by rainfall; but as it is customary to have the field levees only high enough to keep the rice flooded, a heavy rain does not do the canal company much good, as that which falls on fields which are completely flooded overflows the levees and runs off to waste, — often washing down the small contour levees and taking off with it water which has been pumped on, requiring more pumping than if there had been no rain.

It has never been the custom for the canal companies to install reserve units, and, as an irrigated crop cannot go for any great length of time without water, it is of the utmost importance that the irrigation pumping plant be as reliable as it is possible to make it. The plants are usually located many miles from a railroad, or town of any size, and this fact, combined with the short pumping season, makes it almost impossible to keep high

class engine-room help for any great length of time. Even the best-managed canal companies, who pay their engineers by the year and give them good quarters to live in, find great trouble in keeping the same crew year after year.

When it was first found that rice could be profitably raised on the prairie lands of Louisiana by pumping water on to them, almost every known type of pumping machine was tried. These ranged all the way from an immense machine of the pulsometer type having chambers as large as a return tubular boiler, to a triple expansion pumping engine with water plungers 6 ft. in diameter. It can be readily seen that in raising water, as with every other type of machine, the machine having high speed will be cheaper in first cost than those with slower moving parts. For this reason, the centrifugal pump, which at that time was a very inefficient machine but which had high capacity for the amount of metal in it, took the place of the slower speed machines. Even in the earlier days there were a few canal companies who believed in economical plants; and there was one other type of pump which held its own for some time against the centrifugal, and this was the rotary pump, having immense cycloidal gears to displace the water. These were not only more expensive than centrifugals, due to their slower speed and greater weight, but as the passage of water through them was not at a uniform velocity, the pumps were subject to shocks which did not occur with the centrifugal type. The cycloidal pumps showed a very high efficiency, and for this reason held their own against the centrifugal as long as the latter were inefficient; but, with the improved efficiency of the centrifugal, it is undoubtedly true to-day that for the same investment a centrifugal plant can be built which will equal the rotary plant in economy of fuel for a delivered water horse-power.

The Early Plant of Cheap First Cost.

In the early days of rice irrigating, the profits which the canal companies made when conditions were favorable were enormous, and, as the land and water which was available seemed unlimited, every new canal company attempted to put in as great an acreage as possible for the limited amount of money it raised. Under these conditions, it bought pumping plants to give the greatest capacity, regardless of economy, and purchased the cheapest machinery which was offered. Fuel oil was cheap at that time and, in any event, the value of

the single year's crop was about four times the cost of the pumping plant, so that it was useless to advocate economy in fuel consumption. The plants bought under this policy consisted of a cheap centrifugal pump, rope-driven from a simple condensing Corliss engine, the steam being furnished by return tubular or water tube boilers — depending upon the horse-power required. The pipe work was of the cheapest quality, with screwed fittings throughout and no valves which it was possible to do without. I have seen the exhaust from an engine piped directly into a condenser with no outboard exhaust and no gate valve to cut off the condenser for cleaning or repairs. The suction and discharge pipes were made as thin as possible, — so thin that the suction pipes sometimes collapsed from the vacuum when the pump was first started. I have no doubt that the engines were run condensing because it was possible to get a greater horse-power from a given size engine under these conditions, rather than to secure extra economy, and that in many cases they were tremendously overloaded.

The Irrigation Plants of To-day.

Conditions have now changed in the rice country, so that rice raising is on a competitive basis, — the supply each year equaling or exceeding the demand, — and if a rice company wishes to make money it must raise it cheaper than its neighbors. Under these conditions, the companies purchasing new machinery demand and are willing to pay for fairly high economy. In other words, they will buy high-grade equipment if the saving in the three months' pumping will pay interest and depreciation for the whole year. The rice men have learned not only that it pays to buy economical machinery but how to make sure that they get it. It is customary in these days for the rice companies in calling for bids to specify that the bidder shall guarantee the efficiency of centrifugal pumps and steam consumption of the engines, and not infrequently to require an over-all guarantee of the plant in terms of barrels of fuel oil required per day when operating at a given capacity and lift. The equipment usually consists of a high-grade centrifugal pump of the enclosed impeller type, designed for the particular head and capacity which it is to work against. This will be driven by a compound condensing engine. Water-tube boilers are used, except in very small plants, and the auxiliaries are of as high class as are usually found in electric power plants of the same size. The policy of the

company which I am connected with has been to offer main units of the very highest economy which can be purchased, but to keep the auxiliaries as simple as possible. This, we believe, is necessary in order to secure the greatest possible degree of reliability. Under this theory, we often advocate a main pumping unit consisting of a specially designed centrifugal pump direct connected to a 4-valve or Corliss engine, having the best guarantee we can secure, although the cost of this unit may be very much greater than that for a cheaper pump connected to slide valve or marine type of engine. We have advocated the use of high-pressure steam and of having all valves, fittings and fixtures about the plant heavier than is called for by the pressure carried, in order to guard against possible delays due to minor accidents, which would be of small consequence in a plant located near a large city but which would cause delay in one practically isolated from machine shops and supply houses. We have advocated making the condenser and exhaust piping arrangement as simple and safe as possible, but have never advocated the use of high vacuum apparatus requiring separate wet and dry vacuum pumps. We have opposed the use of superheaters, economizers and other equipment which, although adding to the economy of the plant, would at the same time add to the number of different kinds of equipment which the engine-room crew would have to become familiar with.

Details of Design.

The most important feature in designing a centrifugal plant is to get the engine and pump properly proportioned to do the work which you have to perform, as unless this is done you cannot expect good economy. It is, therefore, important that the actual conditions of service under which the plant will be called upon to operate be obtained before selecting the machinery, and it is well in getting these data to check the sources of information. Some purchasers, in order to make sure that the machinery is ample for the service, are apt to overstate their requirements in regard to lift, and, of course, where a plant is designed for a lift considerably higher than it actually has to operate against, the economy will not be what was figured, as the engine will not be operating at best load. In other cases, the purchaser sometimes places too great confidence on the memory of the oldest inhabitant and assumes a low-water mark in the stream from which his supply is drawn which is very much

above the actual low water which may occur under extreme conditions. This also is apt to cause trouble, as, if a plant has to operate against a higher head than it is designed for, it may mean excessive speed for the type of engine selected as well as such troubles as that of insufficient length of suction pipe to reach the water.

Having secured accurate data in regard to what the plant is to perform, the next step is to learn from the pump manufacturers the speed and horse-power which is required for the work. As all of these pumps are designed for the particular service they are to perform, the manufacturers can give a certain amount of leeway in regard to the speed, but usually this leeway is rather limited. When the manufacture of high-grade centrifugal pumps was first begun, the builders gave the impression that they could design them with almost any speed or any characteristic curve which was required. One is apt to find, when using commercial sizes, that the speeds are very limited and that if we insist on any particular form of characteristic curve, we must sacrifice some other desirable feature. In irrigation work, where the lifts vary from 10 to 60 ft., it is nearly always necessary to get the pump builder to run the pump at as low a speed as possible if we wish to direct connect to the engine in order that it may suit the speeds of engines of the required horse-power. With lifts of from 40 to 80 ft., we usually give up the idea of direct connection and use either rope or belt drive. With low lifts, such as are encountered in drainage work, where the pumps are of large size but the horse-power is extremely small, we are always begging the pump manufacturers for higher speeds than they can give, and it is often necessary to cut the speed of the engine down considerably below the speed of its catalogue rating. In other words, it is necessary to buy a larger engine than is needed and run it at a reduced speed. In selecting a pump and engine for direct connection, if high fuel economy is desired, or if the contractor contemplates giving an over-all guarantee as to the fuel consumption of the plant, it is of the utmost importance that we have confidence in the ability of the pump manufacturer to furnish a pump having the efficiency and other characteristics which are guaranteed. This is of greater importance than with guarantees of other equipment, for this reason; in the case of an engine, if a manufacturer gives a guarantee which the engineers who are designing the plant think is too good to be obtained under operating conditions, he can discount the optimism of the manufacturer and use such steam

consumption as he believes the type of machine justifies. In the case of the pump, if we do not believe that the manufacturer will get the efficiency he guarantees, and purchase an engine based on a lower efficiency, then, should the manufacturer secure it, the engine would not operate at best load when the plant was operating under contract conditions. It is even more important that the pump manufacturer shall exactly hit the speed which he figured on than that they shall comply strictly with the economy guarantee. Sometimes a designer who is new in the business will succeed in making a pump which, if run at a speed found by trial, would give the economy and capacity guaranteed, but this speed will be very different from that figured on. As all engine manufacturers base their guarantee on best load conditions, it is easily seen that if the speed of the engine and pump do not suit each other the engine would be either overloaded, or underloaded, and the steam consumption of the whole plant would exceed that figured on in making the guarantee of over-all economy.

In selecting the engine, the speed required is the first condition, as this determines the type of engine which it is possible to offer. We have always given preference to engines of slow speed when it was possible to use them and advocated engines of high economy both on the grounds of fuel saving, and also because the economical equipment is sure to be of better workmanship and design than the cheaper grades of machinery. There are one or two special features which the engine manufacturer should be required to meet. One of these is the type of valve motion to adapt the engine to driving a centrifugal pump. Unlike electrical work, constant speeds are not required in centrifugal pumping; on the contrary, when it is desirable to vary the quantity of water to be pumped, it is necessary to have the speed under the control of the engineer. In other words, driving a centrifugal pump is almost identical with driving a ship's propeller, and the form of valve motion should be one in which the range of cut-off is under the control of the engineer. In order that the engine may not run away should the pump lose its water, it is necessary to have a governor to act as a safety stop, but this governor need not control the speed of the engine at other times as it is desirable rather than otherwise to have the speeds of the pump vary as the lifts vary. It is sometimes advantageous to have the governor control the speed when the steam pressure varies. This may be done on Corliss engines by using a special governor very similar to that used on water-

works pumping engines except that in place of the governor having a pressure control, it has a hand control. On engines of the type which usually have shaft governors, we do away with the shaft governor and use some form of link motion, installing a throttling governor merely as a safety device. This throttling governor normally stays wide open. The link motion which we have used most frequently is that known as the Pious Fink Motion. A modification of the locomotive link has also been used, two eccentrics having the same angle of advance but different eccentricity being installed to give a variable cut-off with constant lead. In coupling the engine and pump, various means are used — in some cases, the two are connected by a flexible coupling, but more generally we use a rigid connection, either a flanged coupling or else a solid shaft passing through both engine and pump.

The design of the suction and discharge pipes is of importance. The centrifugal pump is in reality a machine for giving water a high velocity and then converting the velocity head into pressure head. The velocity with which the water leaves the impeller is dependent upon the lift and is necessarily high, being for the ideal pump of one hundred per cent. efficiency equal to the velocity of a body falling from the same height. This velocity in all well-designed pumps is reduced either by diverging guide vanes or by a diffusion space of gradually increasing cross section. In the large pumps, such as we are considering, guide vanes are not used and the diffusion space merges into the volute or tapering discharge passage. Partly because the water enters the volute at a high velocity, but mainly for commercial reasons, to keep down the cost of the machine, manufacturers have found it expedient to rate their pumps on a velocity through the pipe openings of from 10 to 12 ft. per second. This is nearly twice the velocity allowed through the pipe openings on a reciprocating pump and is sufficiently high to cause considerable pipe friction if the suction and discharge pipes are of any length. This is one of the items where the interest and depreciation should be figured against the difference in fuel on the season's run. If the pipes are short the friction may be neglected, but if they run more than a short distance outside the building, they should be increased to reduce the velocity to, say, 400 ft. per minute. With the lengths of pipe usually required, the friction loss is of minor importance compared to the possible loss due to sudden change in velocity, or to throwing away the velocity head in the water when it leaves the discharge nozzle. When the water

leaves the pump with a velocity of 10 ft. per second, the energy in the form of velocity head is over $1\frac{1}{2}$ ft., and at 12 ft. per second it is nearly $2\frac{1}{4}$ ft. To allow the water to leave the pipe at this velocity is to throw away this head. The same applies on the suction end where the lift may be increased by velocity losses if the suction pipe ends with the same diameter as the pump opening. We, therefore, use large bell mouths on the suction openings and increasers at the end of the discharge pipe. These suction and discharge pipes are made of riveted steel similar to penstocks on other hydraulic plants.

It is well to describe the standard method of priming these steam-driven pumps, as we sometimes find specifications calling for more expensive arrangements, and in every case they are less satisfactory in service than the one in common use. The regular practice is to use no foot valve or other obstruction in the suction pipe, but to locate an automatic check valve or "flap valve" on the end of the metal discharge pipe where it enters the canal, flume or wooden pipe. The pump is then primed by exhausting the air from it with an ordinary steam ejector until sufficient vacuum is obtained to fill the pump with water. Strainers made of steel bars placed across the mouth of the suction to form a very large mesh are sometimes used, but it is better practice to use a strainer crib so that the loss of head through the screen will be readily observed when it becomes obstructed.

Guarantees.

There seems to be a great difference of opinion as to the best form in which to call for guarantees of economy on centrifugal pumping plants. Almost every set of specifications which we have to figure on uses a different wording in calling for guarantees. There is even greater divergence in the way in which bidders figure these guarantees; and it would seem that a clear understanding of the work to be performed would enable engineers to draw their specifications so that bidders would figure on the same basis approximately at least. There seems to be more need for enlightenment on this subject amongst bidders than amongst the engineers who write the specifications. At least, in some recent cases, where it seemed clear enough that the specifications called for overall guarantees on the plant; yet, from the guarantees offered, some of the bidders seemed to overlook altogether many losses, and based their guarantee on the theoretical work of elevating water to a given height — deduct-

ing, of course, for the losses in the pump, but ignoring altogether losses in suction and discharge pipe, loss at entry, velocity head thrown away and other equally important items. In figuring an over-all guarantee of fuel consumption for a plant, all of the losses mentioned below should be taken into account and either figured in detail or allowed for in the final margin of safety. It should be remembered, in the first place, that the pump manufacturer gives a guarantee of pump efficiency for the pump only, and that in the test to determine whether the pump complies with this efficiency the manufacturer would expect the head to be measured at the suction and discharge nozzles. The total head on the pump upon which the pump manufacturer will figure his efficiency is made up of the sum of the following:

The difference in water levels between intake and discharge channels; plus loss through the screen, if there is one; plus velocity loss at entry of suction pipe; plus friction and velocity losses in suction pipe; plus velocity head in suction pipe; plus friction and velocity losses in discharge pipe; minus such part of the velocity head in the discharge as may be recovered by a diverging nozzle.

This total head on the pump is what should be used in figuring the " water horse-power " which the pump is to perform. It is, as you will note, different from the " useful water horse-power " as used by Professor Gregory in his tests for the Government, in which case he figures the useful water horse-power upon the difference in elevation alone. I have never been altogether satisfied that Professor Gregory's useful water horse-power was the proper basis on which to test and compare various plants. In most irrigation plants, it is necessary to carry the water horizontally several hundred feet either in a flume or in a discharge pipe before delivering it into the canal. This transportation of the water horizontally would seem to be part of the useful work which the pump has to do, and whether it is done in an open flume in which the water level may be measured or in the discharge pipe is a matter for the canal company to decide by figuring interest and depreciation against fuel consumption.

Having found the total head against which the pump will operate and the water horse-power which the pump must develop, it is an easy matter to figure the brake horse-power on the pump shaft, if we have the manufacturer's guarantee of the pump efficiency. This b.h.p. at the pump shaft should be divided by the efficiency of the drive, if there is one, to obtain the b.h.p. at the engine shaft; this, in turn, divided by the mechanical

efficiency of the engine will give the indicated horse-power. Having obtained the i.h.p., it is necessary to multiply this by the steam consumption expected under the particular conditions on which we wish to guarantee the plant. These conditions may be best load conditions, or may be overload or underload conditions. The steam consumption of the main unit is, of course, only part of the steam consumption of the whole plant, and we must add for the consumption of the auxiliaries and also for radiation, losses in the pipe system, drop in steam pressure due to friction, and other losses inevitable in any steam plant.

If the boiler manufacturers have guaranteed a certain per cent. of efficiency, and the quality of the fuel is known, we may assume the temperature of the feed water and figure what fuel is necessary for developing the amount of steam required for the plant. Having found this, if we intend to guarantee its consumption, it is well to add a certain percentage as a margin of safety, as it would be too much to expect that on a test every part of the plant would be working under exactly the conditions which were assumed.

On a plant operating against a relatively high lift, some of the losses mentioned may be neglected, but on a low-lift plant they become very important and friction or velocity loss in the suction and discharge pipe which would be ignored on another plant will be a large percentage of the head against which the pump is operating. In these low-lift plants, the velocity head should always be kept in mind both in designing the plant and also in testing.

It is usual for the manufacturers to make the area of the suction opening larger than that of the discharge, and this means that the water entering the pump enters with less velocity head than that with which it leaves it.

In testing to determine whether the pump manufacturer has complied with his guarantee, it is only right to give credit for the excess of velocity head in the discharge pipe over that in the suction pipe, as this velocity head may be recovered by properly designed discharge piping. As the efficiency of any machine is the ratio of the energy output to energy input, the proper method of determining the efficiency of a centrifugal pump would be to charge it with the horse-power delivered to the pump shaft and the velocity head in the water at suction entry, crediting it with head pumped against as shown by gages placed at the suction and discharge openings plus the velocity head in the discharge pipe. It is simpler, however, to take the

difference between the velocity head in the discharge and that in the suction and add this to the total head pumped against. By using a diverging nozzle, the velocity head in the discharge may be largely converted into pressure head and that which remains at the end of the opening of the discharge pipe may still be considered as useful work, provided the delivery is in line with the flow in the outlet channel. In stating the efficiency of the large scoop wheel mentioned later in this paper, the Dutch engineers evidently figured the velocity imparted to the water as useful work and in fact, on the extremely low lifts on which this wheel worked, a good proportion of its work was increasing the velocity of flow.

I hardly know what form of wording to suggest for guarantees, especially on drainage plants. There is no real objection to the guarantee being on water horse-power figured between levels, provided the exact level on which test is to be run is stated, and the bidder knows the lengths of suction and discharge necessary and is to design them. But, recently we were called on to guarantee the fuel consumption per useful water h.p. on any lift between 3 ft. and 6 ft.; in other words, a difference of one hundred per cent. in the working conditions. In such a case, the bidder must either assume the worst conditions or else take a chance on being able to pull off the test when conditions were favorable. I show a curve gotten up to show the varying consumption of a drainage unit operating at constant capacity under varying lifts. It will be noticed that the best load for this unit was 12 ft. and that on lower lifts the steam per water h.p. rises very rapidly. This is due to the fact that the useful water h.p. is rapidly approaching zero, while there are friction and other losses which remain constant as long as constant capacity flows through the pump.

It will be noticed that the "steam consumption per hour" almost follows a straight line parallel with the water h.p. line but which does not start from zero. In other words, the steam consumption of a centrifugal plant operating at constant capacity may be given approximately by a straight-line formula.

It would seem better to call for a guarantee in pounds of fuel per hour under given conditions of lift and capacity. Then should the contract conditions not be obtainable at time of test, it would be easier for the representatives of both sides to agree upon an equitable basis on which to judge the machinery.

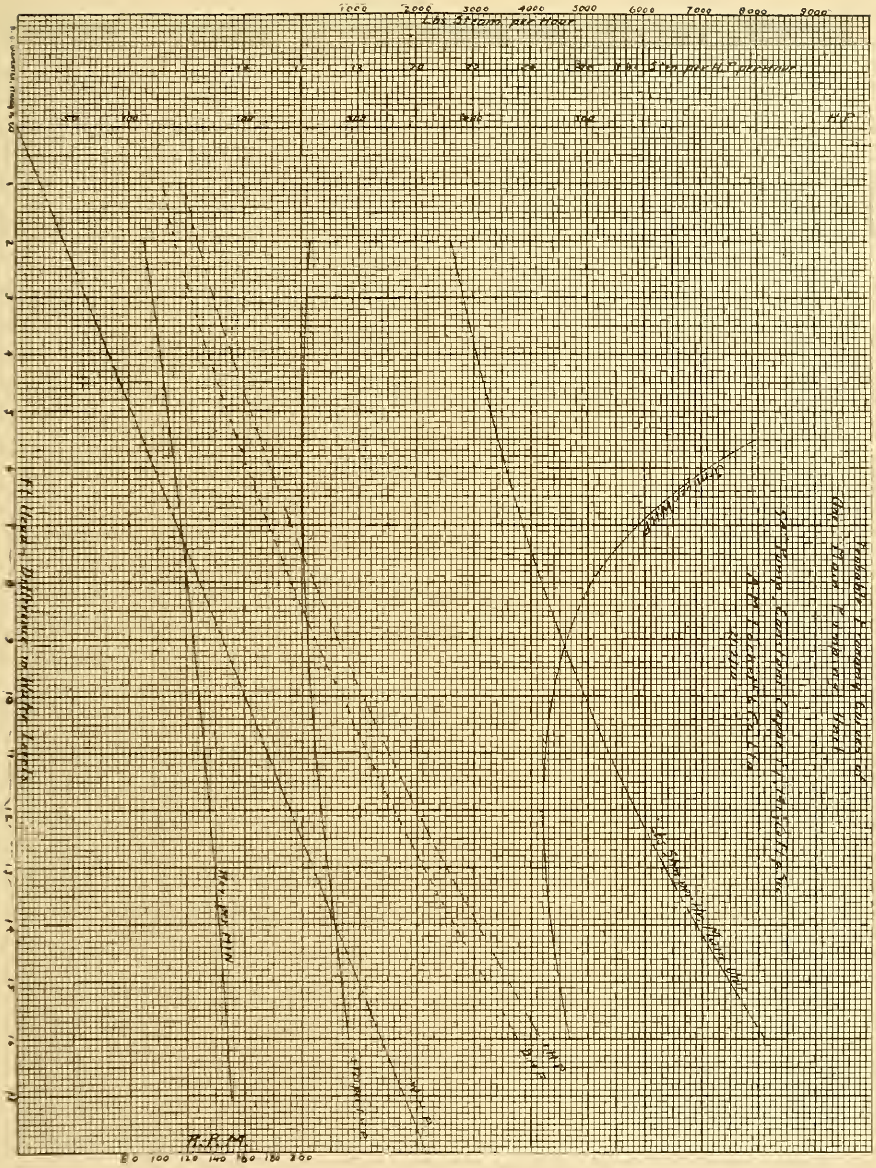


FIG. 1.

DRAINAGE PLANTS.

In regard to drainage plants, I am going to advocate a different type from what some of you gentlemen are installing, but as that is an old difference of opinion between us, it should

do no harm to bring it up again. The plant which I should like to see become standard for drainage work in Louisiana would be one of large capacity consisting of two or more large centrifugal pumps, each direct connected to compound condensing engines of the Corliss or 4-valve type; the steam being furnished by water tube boilers using oil fuel. Such a plant, if the units were of 50 000 to 100 000 gal. per minute capacity, would be ideal from the mechanical engineer's standpoint, as the units would be sufficiently large to get good economy, the engines would run at such speed and be of such horse-power that the very lowest prices could be obtained, and the plant would be large enough to employ skilled labor to operate. I realize that this means the use of one plant for a large acreage, say 10 000 to 100 000 acres, and that this in turn means long canals and a high lift, but I will try to show that the cost of operation, even the cost of fuel, will be less per 1 000 000 gal. gotten rid of by the large plant than the small. I am giving only the point of view of the mechanical engineer. There may be conditions known to the civil engineer or to the farmer which would make the use of large plants out of the question in this territory.

The drainage work which I am familiar with is that in Illinois and Iowa and that in Louisiana. The conditions are somewhat different, and these differences are partly responsible for the variations in engineering practice. In Illinois and Iowa the drainage districts lie along the river bottoms and consist of lands which have a limited natural drainage when the rivers are low, but which are subject to overflow. In the formation of levee and drainage districts, the natural boundaries are usually followed so that each district will have a single outlet with a pumping plant to take care of the rainfall during such time as the river is high enough to prevent gravity drainage. The Bay Island Drainage and Levee District No. 1, a district in Mercer County, Illinois, is typical of the larger plants. It has an area of 20 000 acres and takes the run-off of a smaller district of 4 000 acres additional. This plant was designed for a capacity of 200 000 gal. per minute against a lift varying from 0 to $12\frac{1}{2}$ ft., and consisted of two 60-inch units, all the equipment being of the highest class, designed for high economy.

The smaller plants in Illinois, no doubt, have simple non-condensing engines and are of cheaper construction.

In Louisiana, where the country is flatter, the pumping plant must pump off the rainfall throughout the year. The land which is now being reclaimed lies in the midst of swamp or

marsh, or partly surrounded by lakes or bayous. Being nearly flat, the engineer has the choice of many outfall locations and may install either one large plant or a number of small ones. Obviously, with several small plants draining but a few thousand acres each and pumping to a free outlet at the pumping plant, the lift the pump must work against is low, — not more than 3 to 6 ft. With this lift and units of 36 000 gal. per minute or less, it is out of the question to advocate compound condensing engines of the Corliss type, as the cost per h.p. is out of proportion, due to the small size. Nor can we offer high-grade engines of the type generally used for this horse-power in electric work because the rotative speed of these large pumps is much below that of a generator requiring equal horse-power. No doubt the majority of engineers would consider that a low lift is very desirable and that it means getting rid of the water at a low cost of fuel. As a matter of fact, the fuel for pumping off a million gallons will be less with an economical plant pumping against a 9-ft. lift than with a simple non-condensing plant such as is usually installed pumping against 3-ft. lift. The extra 6 ft. of fall would undoubtedly be sufficient to increase the area which could be drained by from three to nine times the size of that served by the small pump.

The saving in the matter of labor of a large plant over a number of small ones is obvious. The larger plant would require a higher class of help, but this is an advantage as the higher class man is more reliable than the cheaper help. The cost of the machinery for such a plant would be greater than that of several small plants with cheap equipment, but the cost of the complete plant erected would undoubtedly be less for the large than for a number of small plants. There would be many advantages with the large plant and better machinery. If compound engines were used, they could be made to carry great overload if necessary by using live steam in the receiver. If they were cross compound and an accident put one side out of commission, it would still be possible to run; and as the pump is little subject to accident, this feature would practically give a reserve unit.

I have advocated water tube boilers and oil fuel as these features would permit steam to be raised quickly and one fireman could operate a boiler plant of any size required. If the boilers are of the sectional water tube type similar to those used in naval work, steam may be raised in thirty minutes without danger to the boiler. With automatic oil-fuel pumps, one man could, if necessary, operate a plant in an emergency. In fact,

there is one irrigation plant which I know of which is operated by one man who attends the boiler and engine. It is a compound condensing engine of 225 h.p.

Cost of Plants.

The question as to the approximate cost of a plant of a certain capacity and lift is often asked by engineers and others who are making preliminary estimates. In fact, this is the first question which the prospective customer is apt to ask. Although we have several rough rules for figuring these costs, none of them is satisfactory as applying to both drainage and irrigation plants. It has been the custom in making rough estimates of pumping plants designed for lifts of from 25 to 40 ft. to figure them at $80 to $100 per water horse-power, but one will readily see that the same figure will not apply to a drainage plant of like capacity pumping against a head of 3 ft., as the cost of the pumps, suction and discharge pipes, etc., would be very nearly the same for the low-lift plant as for the high-lift, whereas the horse-power would be so small as to put the plant in a different class altogether from the one with the higher lift. In order to be able to give approximate figures I endeavored to tabulate the various bids which the concern I am connected with has made on pumping plants within the last ten years, and found that a tabulation, or even a curve, of these bidding prices would be of little value, as in some cases we bid including the building, foundations and even intake work, whereas in others our price was merely for machinery f.o.b. cars, or again for machinery erected on foundations built by the purchaser. To make a comparison, therefore, I decided to take the cost of all the mechanical equipment necessary for the plant, and using our costs sheets as a guide make up curves which would represent these plants erected ready for operation at some point in Louisiana or Texas; in other words, I have assumed, what is very far from the fact, that the cost of freight, barging, foundations, erecting, etc., is a constant percentage. This is done because it is not the intention that this diagram of costs shall be used for obtaining actual costs of plants but that it shall be relative only and be used for the purpose of deciding the most economical size of units to use in a large plant and also for making approximate estimates on the assumption that a plant of two or more units will be a multiple of the cost of a single unit plant. In this diagram, I have not included the building, as the cost of this would depend

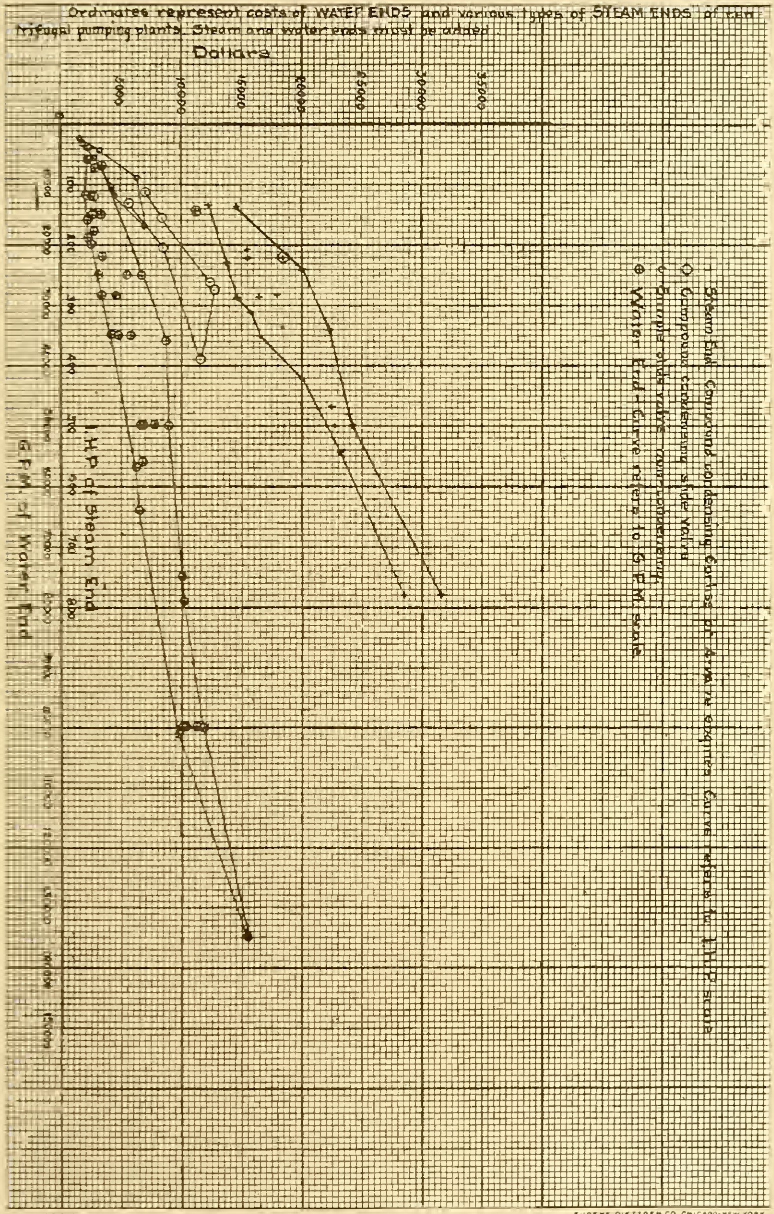


FIG. 2.

Diagram showing comparative approximate costs of single-unit centrifugal pumping plants erected complete, inclusive of foundations but exclusive of buildings, intake, discharge canals or flume. Based on estimates for work in Louisiana and Texas.

H. L. HUTSON, Louisiana Engineering Society.

upon the style of architecture, nor have I included any dredging, intake work, flume or canal work. I did include the building foundation, as it is usually necessary to place a pumping plant in a pit, in which case the pit walls form the building foundation, and the pump foundation, engine-room floor and walls are made monolithic.

For the reasons above given, it will be impossible to make smooth curves using either the water horse-power or the gallons per minute as one of the coördinates. It seems more logical, therefore, and gives data which are much more useful, to divide the plant into two parts, and consider it merely as a steam-power plant, which drives a pumping plant. I have, therefore, divided the cost into two parts: cost of the " steam end " and cost of the " water end," but showed these on the same sheet. In using this diagram it is very important that this fact should be borne in mind and that the cost of the " water end " should be added to that of the " steam end." The cost of the " water end " is given in terms of gallons per minute at the rated capacity. The cost of the " steam end " is given in terms of indicated horse-power and it is, therefore, necessary to figure this horse-power by assuming the combined efficiency of the engine, drive (if there is one), pump and piping. It will be noticed that it is necessary to use zones instead of lines to indicate these costs, the variation being due to numerous causes. The zone marked " *Water end* " covers pumps, suction and discharge pipes, and is the only one which refers to the gallons per minute scale at the bottom of the diagram. The zone marked " *Steam end, compound condensing Corliss or 4-valve engines* " covers the complete steam plant equipment including this type of engine with water tube boilers. The zone marked " *Compound condensing slide valve* " covers this type of engine with either water tube or return tubular boilers depending on the size of plant. The zone marked " *Simple slide valve non-condensing* " covers the type of engine indicated with horizontal return tubular boilers.

Engineers in comparing these costs with other power plant costs may decide that I have made them unnecessarily high even for approximate figures, but it should be remembered that practically all of these plants are installed between the high- and low-water mark of the stream on which they are situated, and that in the case of drainage plants they must almost invariably be put in on the land which they are to drain. The freight rates throughout this territory are high and the problem of transporting material from the railroad to the site of the

plant is always a difficult one, as it usually means either hauling many miles over roads which are sometimes impassable, or barging on streams that are seldom navigated. All of these plants go in near the coast on land more than one hundred miles from the location of any stone suitable for concrete. On one occasion the best quotation which we could get on sand or gravel delivered on barge at the site of the plant was $4.00 per yard, and yet this plant was located on a stream supposed to be navigable. On one drainage plant there were ninety days in which the water was either at or near the floor line and the erection work had to remain at a standstill. This same plant when completed could not be tested for lack of water to give contract conditions. In the case of every plant on the Rio Grande for which we have furnished equipment, the river has overflowed between the times when the machinery was delivered and the completion of the plant. This overflow has flooded the valley for eight or ten miles from the plant.

If the curves were carried out a little further they would show the fallacy of a belief which many people have that simple slide-valve engines and return tubular boilers form the cheapest equipment which can be furnished under all conditions. Many saw-mill owners purchased this class of machinery with the idea that they are not interested in economy and, therefore, should buy the cheapest class of engines. Where the horse-power required is 400 h.p. or above, they could undoubtedly buy compound condensing equipment with the necessary horse-power of water tube boilers, and the cost of the complete plant erected, including building, would be much below that of the uneconomical plant.

It is interesting to compare the cost of a centrifugal drainage plant with that of a large scoop-wheel plant of the better class. Mr. Chas. S. Slichter published a very interesting article in *Engineering News** describing the scoop-wheel pumping plant at Schellingwoude, Holland.

This plant has a capacity of 1 500 cu. ft. per second for lifts under 1.8 ft. and can pump against lifts as high as $6\frac{1}{2}$ to 7 ft. The economy is all that could be desired as the steam consumption in actual operation varies from 31.7 to 37 lb. of steam per hydraulic horse-power, the efficiency being between 60 and 70 per cent. for scoop wheel and engines. The cost of the complete plant, however, is very much greater than that of a centrifugal plant to do the same work, as shown by comparing the

* *Engineering News*, May 19, 1910.

scoop-wheel plant with a drainage plant on which bids were recently taken in this country. The cost of the Schellingwoude scoop-wheel plant, as given by its chief engineer, was as follows:

Excavation	$30 800
Foundations	44 000
Buildings	85 600
Machinery and boilers	66 600
Coal handling and storage	2 890
Traveling crane, superintendence, rebuilding of dwelling houses, etc.	13 900
Total	$243 790

The centrifugal plant which we refer to was to have a capacity of 1 800 cu. ft. per second against a head of 8 ft. The company I am with were low bidders on this work, the bids being

For machinery erected	$132 500
For foundation and building	51 500
Total	$184 000

I had intended to give figures to show that the cost of pumping was in many cases less than the interest and maintenance on many gravity irrigation projects, but this seems unnecessary.

The customary charge of the rice canal companies for water is $6.00 per acre for the season. This is less, I am told, than the cost of maintaining the ditch system on some of the coöperative ditches of the West.

DISCUSSION.

Mr. W. B. Gregory. — The paper under discussion covers a wide field. It is my purpose to discuss only a few of the points raised, along lines with which I am most familiar.

It has been my good fortune to make efficiency tests of some sixty-odd pumping plants, large and small, used for rice irrigation or drainage, and among them are several designed and erected by the firm with which the author of this paper is connected.

It is my firm belief that we usually fail to realize the enormous size of some of these plants, although we often hear the statement that the pumping plants of the rice country are the largest in the world used for irrigation, when rated on volume of water discharged. There are pumping plants in Hawaii that

No.	Name of Plant.	No. of Units.	Type of Engine.	I.H.P. Each Unit.	Type of Pump.	Lift in Feet.	Gallons per Min. Pumped.	Gal. per Min. Pumped, Total Plant.	Efficiency of Pump, Per Cent.	Pounds of Fuel Oil per Useful W.H.P. per hr.
1	Abbeville	2	Comp. Cond. Corliss.	155.6	Rotary.	15.5	32 560	65 120	88.0	2.48
2	Neches	6	,, ,, ,,	328.8	,,	31.6	34 310	205 860	89.5	2.09
3	Jennings	1	,, ,, 4-Valve.	221.4	Centrif. 30 in.	24.0	25 760	25 760	75.4	2.16
4	Onishi	1	(Vertical Comp. Buckeye.)	230.4	,, 24 ,,	37.2	14 610	14 610	63.0	2.82
5	Cane and Rice Belt, 1st Lift	2	Comp. Cond. 4-Valve.	585.3	,, 45 ,,	31.6	47 620	95 240	69.6	2.33
6	Cane and Rice Belt, 2d Lift	2	,, ,, Corliss.	221.3	,, 45 ,,	13.2	46 430	92 860	75.0	2.31
7	Sabine Canal	1	,, ,, ,,	370.2	,, 45 ,,	20.0	44 010	88 020	77.3	2.29
8	Moores Bluff	2	,, ,, 4-Valve.	793.4	,, 36 ,,	55.9	39 707	79 414	78.5	1.96
9	Grand Canal	1	,, ,, Corliss.	452.3	,, 36 ,,	31.6	38 440		73.0	2.14
10	Trespalacios	2	,, ,, ,,	414.2	,, 36 ,,	26.9	38 200	76 400	68.2	
11	Pierce Estate	2	,, ,, ,,	449.0	,, 36 ,,	34.4	40 100	80 200	67.9	2.84

elevate the water to a much greater height, but the quantity pumped per unit is less than 20 cu. ft. per second. Even in California water is pumped to a height of 247 ft. in one case with which I am familiar, yet in the latter plant the quantity of water is so small that the indicated horse-power per unit of the steam end of the pumping engine is only 216, which is small when compared with many of the units of the rice country.

In order that we may refresh our memories, the preceding table has been prepared, giving some of the details of the large plants.

It will be seen from the table that all the engines used are of the compound-condensing type. Most of them are of the Corliss type. This table gives the results of the modern plants of good design. Many of the older plants showed, in carefully conducted tests, results that were startling. I have in mind one in particular that was typical of a class in the early days of rice irrigation. On the basis of water horse-power computed on actual lift the pounds of fuel oil per hour were 9.61. It is conceded by all who have made a study of this problem that the compound condensing engine is the only type of steam engine to use in an irrigation pumping plant of any size.

In the above table the first two plants have rotary pumps. They are introduced because the capacity of the Neches Canal plant is of interest and incidentally because they furnish evidence confirming a statement in the paper concerning relative economy. While the efficiency of these pumps is sufficiently high to test one's credulity, the net showing of the plant is no better than for some of the centrifugal outfits. The result given for the Neches was obtained by running two units, and the fuel consumption was lower than it would have been for a single unit.

The efficiencies given for the rotary pump should be stated for pump and piping. The pipes were so large that the loss in them was a very small quantity. For all the centrifugal pumps the efficiency stated is for pump alone. That is, it is based on "head on pump." We can only make intelligent comparison of pumps in that way, because length of suction and discharge pipe will vary according to local conditions. A pump should be credited with all the energy it imparts to the water because if the piping system is properly designed fairly high velocities in a centrifugal pump are not objectionable.

Several years ago, when acting as consulting engineer of the Mississippi River Commission, this fact was brought home to me in testing the pumps of their large hydraulic dredges.

These pumps take water on the suction side at the level of the river and discharge it practically at the same level or at most 2 or 3 ft. above the surface of the water. The mean velocities employed vary from 15 to 22 ft. per second, in order to carry a large amount of solids, and the velocity head is correspondingly high, or from nearly 4 ft. to 7.5 ft., and to ignore this velocity head would lead to serious errors.

But the hydraulic dredge is a special adaptation of the centrifugal pump, and it has always been my belief that in a pumping plant used for irrigation or drainage, while it is desirable to know the "head on pump" in order to judge the performance of the pump as a machine, the main point to be kept in mind, so far as economy is concerned, is the cost in fuel in elevating water from the level of suction to that of discharge. This is emphasized by the fact that under ordinary circumstances the losses at entrance to a pipe and the kinetic energy thrown away at the discharge end of a pipe may be reduced to very small quantities. In other words, pumps should be judged individually and each given equal opportunity, but pumping plants should be judged on the entire equipment used to elevate water from one level to another.

Time will not permit a discussion of the details of design of pumping plants of this type. There is, however, one point to which your attention is especially invited, as it is one where designers have often made mistakes that involved the waste of much energy and consequently of fuel and of money. The velocity of water at entrance to the suction pipe must be low because ordinarily 93 per cent. of the velocity head is lost at entrance. The velocity head thrown away at the end of the discharge pipe is usually a total loss also. By doubling the diameter of the ends of suction and discharge pipes by means of nozzles of a conical shape, the velocity for a given amount of water pumped is only one fourth of that for a straight pipe, and as the velocity heads vary as the square of the velocities, for the enlarged pipe, the losses are only one sixteenth of those for the straight pipe.

In a recent publication for the United States Department of Agriculture* I have endeavored to show the gains to be effected by the enlarging of suction and discharge pipes and have given the details of the computations involved.

It may be assumed by some engineers that the saving to be effected in this way is so well known to the members of the

* "The Selection and Installation of Machinery for Small Pumping Plants." Office of Experimental Stations, Circular 101, 1910.

profession who design large pumping plants that it is unnecessary to call attention to a fact that is so fundamental. Unfortunately this is not the case. Last summer the writer was called in as consulting engineer on one of the largest pumping plans for drainage that has ever been designed. Some of the plans submitted showed that the designers were profoundly ignorant of any gain to be derived in this way. The reckless guarantees of fuel economy and the lack of knowledge of details that are absolutely essential to economy of operation spoke eloquently of lack of experience and of perfect faith in the various elements of the pumping plant to make their best showing in spite of impossible handicaps.

The author has stated that the pumping plants for drainage are not yet standardized to the same extent as irrigation plants. European engineers nearly always employ the high-grade plants, and it seems probable that the tendency in this country will be in the same direction. Here is a problem that merits careful attention, for the next ten years will see hundreds of thousands of acres of our rich alluvial lands reclaimed. The information is being collected on which to base intelligent designs of these plants, and with all the factors known the best results will be realized.

Mr. A. M. Shaw. — It would appear presumptuous for one whose experience has been almost entirely confined to the work of the civil engineer to discuss this paper of Mr. Hutson's were it not for the fact that he has, with evident purpose, presented an opening along lines not strictly within the field of the mechanical engineer.

A study of drained areas as they affect the design of pumping plants is considered especially desirable. It has been shown that in the case of extremely low lifts, such as obtain in the drainage projects of this locality, the actual lift may be considerably increased without greatly increasing the load on the pumps or the total cost of pumping. In the low lands of Louisiana, where there is practically no natural slope of the surface and where the grade necessary to create suitable flow in drainage canals must be supplied artificially, it is evident that an increase in size of unit must mean an increase in head at the pumps. The economical limit in the size of units will have been reached when the cost of raising the water to the height necessary to produce a satisfactory stage of water in the canals and flow in the farthermost ditches is equal to the benefits derived by a centralization of equipment *plus* the saving which the large unit effects in the

construction of outer protection levees and interior canals. Among the material advantages offered by the large unit is the possibility of incorporating into the general interior drainage scheme the small lakes and larger bayous of the region. This often results in a large saving in original cost of construction which it would be impossible to secure if the same property were to be cut up into small drainage units.

In drainage units supplied with liberal storage capacity the necessary excavation may be distributed in such a manner that the various canals may collect the water and bring it to the pumping plant with a surprisingly small loss of head. Assuming a unit consisting of a full township of 23 040 acres, a main or trunkline canal might be constructed having a width of 150 ft. or more and a depth of 9 or 10 ft. Assuming the pumping plant to be located at one corner of the tract, this trunk canal would probably run from this corner to the center of the tract, a distance of $4\frac{1}{4}$ miles. Maintained in proper condition, such a canal would carry the maximum run-off of the tract with a gradient of about two tenths of a foot per mile, or less than a foot in its entire length. Careful study should be made of each ditch scheme in order that the ditches may collect the water from the field laterals in the minimum time and make delivery to the pumps with such regularity that the plant may be operated with the maximum of economy and efficiency.

The economical location for the pumping station will usually be found to be at some point on the outer boundary of the tract, though it is often found desirable to locate the plant at some more central point. This latter plan results in the construction of an outfall canal, the excavation from which is not utilized for storage, and also requires the construction and maintenance of an added length of protection levee. In localities not subject to high tides this latter point may be disregarded. An excellent example of the central location of pumping plant is found on the Myrtle Grove plantation where the pumps are placed in the interior of the tract near rail transportation and convenient to the plantation headquarters. One battery of boilers serves the pumping plant and a fairly complete saw mill, and the refuse from this mill furnishes fuel for a large part of the pumping.

Another advantage which the large unit has over the small one is the economy in handling large but local rains. On one tract of 2 400 acres a rainfall of one inch was recorded at the front of the plantation while there was scarcely a trace of rain at the pumping station. This rain caused a rise of water in the

reservoir of a few inches and one of the pumps was operated for about two hours, but it is possible to conceive that on a still larger tract the water from such a storm might be taken care of by the reservoir system and later lost by evaporation without the necessity of starting the pumps.

In the foregoing discussion it has been attempted to show that the designer of the pumping plant is not alone in his demand for larger areas to be served by a central pumping station, but that the larger unit idea will make for economy in many other lines of work which enter into the reclamation of the prairie lands of the Gulf coast.

Mr. A. T. Dusenbury. — In his paper read at the last meeting of this Society, Mr. Hutson described a pumping plant which he considered to be of a proper size for use in the reclamation of Louisiana's wet prairie lands. In his judgment, tracts containing from 10 000 acres up to 100 000 acres should be included in one reclamation unit. It may be that units comprising such large acreages will eventually become popular, but our company has given this matter a good deal of careful study and has come to the conclusion that, all things considered, plants to handle the run-off from units containing not to exceed 5 000 acres are best.

Mr. Hutson gave only the point of view which might be taken by a mechanical engineer working for efficiency, giving little attention to other very essential matters which must be carefully considered, but inasmuch as the entire cost of operation and maintenance of our various small plants has not exceeded 50 cents per acre per year, and one track of 2 400 acres was pumped at a cost of 35 cents per acre, we consider the economies to be effected in pumping plant construction to be of relatively small moment, many other things having to be taken into consideration before the size of a reclamation unit is finally decided upon.

Topography. — In the first place, owing to topographical conditions, sometimes the size of the unit, called by the Dutch a "polder," which otherwise would be desirable is found to be impossible. The territory in South Louisiana is so cut up and interlaced with bayous, lakes and rivers, of more or less depth, that it may be practical to include no more than 1 000 acres in a polder, and then again seven or eight thousand acres may best suit the local conditions. Again, heretofore, some small land owner who preferred duck ponds and mosquito beds to cultivated lands could block a certain drainage proposition, but the new

drainage law passed by the last session of the legislature makes it possible to vote such a man into a district whether he wants to come in or not, and he thus will be benefited in spite of himself.

Cost. — Our company has recently confined itself to small units, ranging from 1 000 acres to 2 500 acres, one of its reasons for so doing being the lack of available funds. We had worlds of land, but no ready market for it. It took all the money we could raise to advertise Louisiana, to attract the attention of men of means to the possibilities offered by the reclamation of our wet lands and also to bring settlers down here, it being impossible to sell reclaimed lands to local farmers.

As it takes from $20 to $30 per acre, according to local conditions, to reclaim a tract, we found it necessary to work on small units, utilizing our money to the best advantage possible. We have, however, now adopted approximately 5 000 acres as the most suitable sized unit, and we have one polder containing this acreage well on its way to completion and will start on another of the same size within a few months.

It is most gratifying to note the change in attitude of the northern investor and farmer towards Louisiana and to see how much easier it is now to induce them to come down here and look our lands over, but in the past it was exceedingly discouraging. We believe now that we can colonize a tract just as soon as it is reclaimed, but when this is not done, as has heretofore been the case with us, the surface ditches grow up with luxuriant grasses of almost infinite variety and they become clogged with a fine material which washes out of the soil during the first few months after they are dug. If, then, the purchaser of these lands does not arrive on the ground in time to keep the ditches clean, the land cannot long be kept dry, and much of the initial work would have to be re-done by the land company, thus adding considerably to the reclamation expense, in addition to which the interest on the investment in the unsold portion of the lands is no small item.

This matter of colonization should be well studied and thoroughly understood before the size of polder is finally decided upon.

Transportation. — Southern Louisiana will, in a short time, be a second but larger Holland; however, it will be many years before a network of railways is spread through this territory. For transportation purposes, then, canals are absolutely necessary. In reclamation units of approximately 5 000 acres the longest haul by wagon that the farmer will have is about one

mile; but, in view of our protracted rainy season, and the nature of our soil, one mile is as long a haul as he should have. He can then put his produce on boat or barge and deliver it by water to the nearest railway station, sugar mill or wherever his market is.

Water transportation is the cheapest kind of transportation, and when this method is thoroughly appreciated by the farmer he will be sure to select his farm on a navigable waterway, rather than a railroad, if it so happens that he cannot have both.

Danger. — So far all our reclamation work has been done with little thought of the possibility of overflow, due to crevasses in the levees of the Mississippi River. We are all hoping that there will be no further crevasses, and that if one should occur, it would be closed before the flood waters rose to dangerous heights; but should high water appear from this source or from a Gulf storm, and a portion of the levee surrounding a certain polder against which the flood comes prove defective, as is very possible, it were better that such a polder be a very small one, the smaller the better.

The reclamation of Louisiana's wet lands has only just begun, but already a goodly number of competent engineers are engaged in the work, and while at present their operations are largely experimental we can hope that before many years elapse from the experience gained by these engineers and from the actual working out of the polders now reclaimed and being cultivated, we shall be able to know definitely how to handle all the problems involved in reclamation work.

Mr. H. L. Hutson. — I was much interested in the discussion, particularly that of Mr. Dusenbury, as we all recognize that he speaks with the authority of experience. What interested me most in his discussion was the figures he gave of the cost per acre of reclamation by drainage and the annual cost of operation. I had collected some figures of the cost per acre on the United States Government's reclamation projects in the West, where the work is that of irrigation, and it is interesting to compare them. Mr. Dusenbury stated the cost of reclamation of wet lands in Louisiana as $20 to $30 per acre, and the annual cost of operating as 35 to 50 cents per acre. Compare these with the following:

	Per Acre.
Salt River Project, Arizona.	
Estimated building charge	$40.00
Yuma Project, Arizona.	
Estimated building cost	50.00 to 60.00
Sun River Project, Montana.	
Estimated building charge	30.00
Annual operation and maintenance charge	0.50
Lower Yellowstone Project, North Dakota.	
Estimated building charge	42.50
Annual operation	1.00
North Platte Project, Nebraska and Wyoming.	
Estimated building charge	35.00 to 45.00
Annual operation	2.00

I understand that the Government does not include interest on investment in the annual operating charge.

It will be seen that the reclamation by drainage of the wet lands in Louisiana is a far more profitable commercial venture than the irrigation projects of the West, and that the annual charges to the settlers can be as low or lower than those for irrigation by gravity.

I give in an appendix information from several sources regarding some of the drainage plants in Illinois and Iowa. The costs of these projects as well as the pumping capacities selected for various acreages will no doubt interest members of this Society. The published sources of these data are given so that those who wish to go more deeply into the data may do so.

The table given by Professor Gregory is particularly interesting, as it gives a comparison of the performance of different types of plants which only he could give, and gives data many of which were unpublished heretofore. Of the six plants he enumerates which were installed by the company I am connected with (namely, Nos. 3, 4, 5, 6, 7 and 8), I think the test of only one (Jennings) has been published.

EXTRACT FROM *Engineering News*, NOVEMBER 17, 1910.

The information given below as to the work in Illinois is condensed from an article by Mr. J. A. Harman, M. Am. Soc. E., of Peoria, Ill., for the *Herald-Transcript* of that city.

DRAINAGE DISTRICTS IN THE ILLINOIS RIVER VALLEY.

District and County.	Area, Acres.	Approximate Cost.	Approximate Pumping Capacity per Hour, Gallons.	
1. Hennepin (Putnam)..	2 500	....	....	Under construction.
2. Partridge (Woodford),	3 000	$100 000	1 000 000	Nearly completed.
3. East Peoria (Tazewell).............	750	55 000	800 000	Not begun.
4. Pekin and LeMarsh (Peoria)..........	2 600	100 000	1 000 000	Completed.*
5. Spring Lake (Tazewell).............	14 000	300 000	9 000 000	Nearing completion.
6. Banner (Peoria and Fulton)...........	5 000	150 000	3 000 000	Not begun.
7. Lacey (Fulton)......	5 700	....	(2) 2 000 000	Completed.*
8. Coal Creek (Schuyler),	7 000	....	2 000 000	Completed, 1898.*
9. Crane Creek (Schuyler)...............	5 000	135 000	....	Nearly completed.
10. Meredosia (Morgan)..	5 000	101 000	1 000 000	Completed, 1904.*
11. Magee Creek (Brown),	12 000	....	3 000 000	Completed, 1908.
12. Scott (Scott)........	12 000	168 000	....	Not begun.
13. Big Swan (Scott)....	12 000	200 000	3 000 000	Completed, 1908.
14. Hillview (Scott and Greene)...........	11 000	275 000	2 500 000	Completed, 1909.
15. Hartwell (Greene)....	12 000	....	(Note)	Completed, 1907.*
16. Keach (Greene)......	10 000	....	....	Completed, 1908.*
17. Eldred (Greene).....	9 000	250 000	3 000 000	Under construction.
18. Nutwood (Greene and Jersey)	11 000	279 000	6 000 000	Completed, 1910.

* NOTES. — (4) Levee completed, 1889; first pump installed, 1904; levee rebuilt and new pump installed, 1907.

(7) Completed about 1893; first pumping plant, 1900; second pumping plant, 1906.

(8) Ditches rebuilt, 1909.

(10) Pumping capacity now being doubled.

(15) Two pumping plants serve portions of the district. The levees were rebuilt after being broken by the high waters of 1902 and 1903.

(16) Pumping plant recently installed.

EXTRACT FROM PAPER READ BY JOHN J. HARMAN, M.E., OF PEORIA, ILL., BEFORE THE ANNUAL MEETING OF IOWA DRAINAGE ASSOCIATION HELD AT MASON CITY, IA., FEBRUARY 14, 15.

(Copied from *Brick and Clay Record*, August 15, 1911.)

Name and Location of District.	Approximate Acreage.	Approximate Cost of Improvement.	Size of Pumps.	Capacity of Pumps.	Date of Completion.
Drury Drainage District, Rock Island Co., Illinois.....	5 000	....	1 45-in. Pump.	50 000 G.P.M.	1910.
Drainage Union District No. 1, Rock Island Co. and Mercer Co., Illinois............	4 000	....	Drains into Bay Island, D. & L. D. No. 1.	....	1908.
Bay Island D. & L. D. No. 1, Mercer Co., Illinois.....	20 000	$242 000	2 60-in. Pumps.	200 000 G.P.M.	Pump plant completed 1910. Levee and ditches will be completed in 1910.
Keithsburg Drainage District, Mercer Co., Illinois...	1 350	52 500	1 18-in. 1 12-in.	13 500 G.P.M.	Under construction.
Louisa-Des Moines D. D. No. 4, Louisa Co. and Des Moines Co., Iowa,	13 000	97 600	2 45-in. Pumps.	100 000 G.P.M.	Pumping plant 1909. Ditches 1910.
Des Moines Co., D. D. No. 1, Des Moines Co., Iowa,	28 000	326 000	Main Plant, 3 54-in. Ext. Plant, 1 24-in. 1 18-in.	Main Plant, 240 000 G.P.M. Ext. Plant, 27 000 G.P.M.	Under construction.

[NOTE. — Discussion of this paper is invited, to be received by Fred. Brooks, Secretary, 31 Milk Street, Boston, by July 15, 1912, for publication in a subsequent number of the JOURNAL.]

WATER RESOURCES OF MINNESOTA.

By Geo. A. Ralph, Member of the Civil Engineers' Society of St. Paul.

[Read before the Society, February 12, 1912.]

Minnesota lies in three great continental watersheds. From her surface the water flows northward by Red River of the North and Rainy River into Lake Winnipeg, and on to Hudson's Bay; eastward by St. Louis River into the Great Lakes, and through the St. Lawrence to the Gulf of St. Lawrence; and southward through the Mississippi to the Gulf of Mexico. Her lakes, springs and streams are the fountainheads of the three greatest river-systems in North America, the headwaters of which are all within a radius of fifty miles.

The Mississippi rises at an altitude of 1 472 ft. and leaves the state at an altitude of 615 ft. The Red River of the North rises at an altitude of 1 500 ft. and crosses the international boundary line at an altitude of 748 ft. The St. Louis rises at an altitude of 1 700 ft. and flows into Lake Superior at an altitude of 602 ft.

These three watersheds within the state have widely different physical features. The watershed of the St. Louis is rough and hilly. The banks of the streams are usually high and steep, and in many places are rocky gorges. The landscape in its natural condition was heavily wooded, with here and there a patch of meadow or open muskeg. The streams have, as a general thing, swift currents, and rarely overflow their banks.

The watershed of the Rainy River is similar in many respects to that of the St. Louis, but with more extensive swamp areas, which are generally sparsely timbered. The watershed of the Red River of the North consists largely of prairie land, much of which is nearly level, the upper portion, or about one fourth of it, being timbered. The banks of Red River are generally low, varying from twenty to fifty feet above ordinary low water. The current in the lower reaches of the river, or below Breckenridge, is sluggish, the average fall per mile of stream being less than four tenths of a foot.

The watershed of the Mississippi is a composite of the St. Louis and the Red River of the North, the upper portion and the

eastern slope being generally rolling with a heavy forest cover. In places the banks of the streams are steep and rocky. The streams, with few exceptions, have swift currents and seldom overflow their banks farther down the watershed and along such streams as the Crow, the Minnesota and its tributaries, the Cannon, the Zumbro and the Root rivers. The watershed is similar in many respects to that of the Red River of the North, and consists largely of open prairie land; the streams in many places have low banks, tortuous courses and sluggish currents. As a consequence, many of these streams overflow their banks in time of high water.

Few, if any, of the states of the Union can compare with Minnesota in the number and grandeur of the lakes within their borders. It is estimated that there are ten thousand lakes wholly or partly within the state, seven thousand five hundred of which are meandered lakes and known as public waters.

Minnesota's many beautiful waterfalls have never been properly described or fully appreciated. No history or geography of the state gives more than a cursory description of a few of the most important waterfalls. On almost every stream flowing into Lake Superior in northeastern Minnesota are found waterfalls the grandeur of which is unsurpassed.

The Pigeon River falls 600 ft. in a distance of twenty miles. In one place there is a vertical fall of 130 ft.; in another, 83 ft.; in another, 52 ft. and again 25 ft. This stream flows through a rocky gorge for fifteen miles before it empties into Lake Superior; in places the rock banks are 250 ft. high and almost perpendicular.

The Brule River has a fall of 750 ft. in a distance of six miles before emptying into Lake Superior.

The Cascade River falls 810 ft. in a distance of six miles.

The Poplar, 620 ft. in three miles.

The Temperance, 460 ft. in three miles.

The Cass, 850 ft. in eight miles.

The Baptism, 710 ft. in nine miles.

The Beaver 290 ft. in one mile, and 470 ft. in six miles.

The Gooseberry, 230 ft. in two miles.

Each of the above-named streams has many beautiful waterfalls. On some the falls are similar to those on Pigeon River, on others there is a series of rapids and small perpendicular falls varying from four or five to twenty feet in height. The beautifully wooded landscape, where almost every kind of trees and plants native to Minnesota can be found; the rugged nature

of the country; the high, rock-walled channels of the streams; and the music of the falling waters, — all combine to make the north-shore streams of Lake Superior the most enchanting in North America.

But these are not the only streams in Minnesota where beautiful waterfalls are found. The falls of the Kawishiwi and Vermilion, tributaries of Rainy River, are fully as picturesque as those of the north-shore streams. Kawishiwi has a fall of 70 ft. in a distance of two and one-half miles. The Vermilion falls 85 ft. in a distance of one fourth of a mile at one place; 52 ft. in a distance of three miles at another place; and 88 ft. in a distance of two and one-half miles in another.

Koochiching Falls on Rainy River are both beautiful and awe-inspiring. Here, under natural conditions, 16 000 cu. ft. of water per second rolled over a granite ledge and down through a rocky gorge, falling 30 ft. in less than half a mile.

Big Fork River at Big Falls, Minn., falls 35 ft. in one fourth of a mile.

The St. Louis in its natural state had many beautiful waterfalls and rapids, the grandest of which was the Great Falls at Carlton. Here the St. Louis tumbles down a rocky gorge, falling 375 ft. in a distance of three miles.

The Ottertail River falls 200 ft. in a distance of twenty miles.

The Red Lake River, 270 ft. in forty miles.

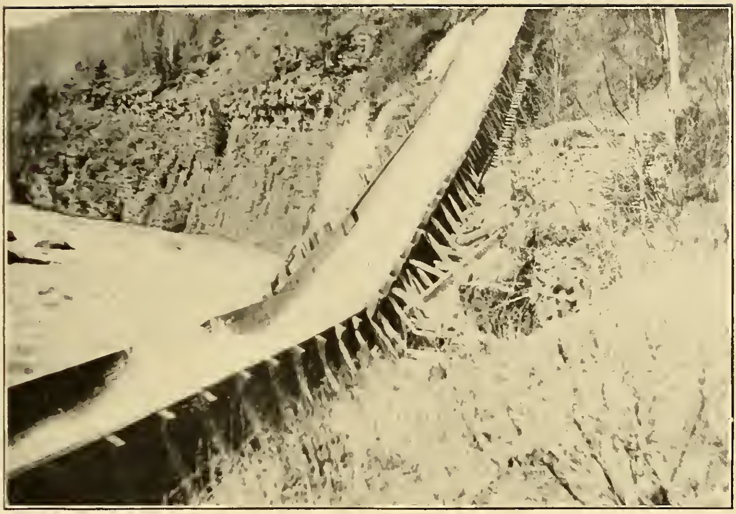
The Minnesota River falls 50 ft. at Granite Falls in a distance of one mile.

The St. Croix River falls 63 ft. at St. Croix Falls.

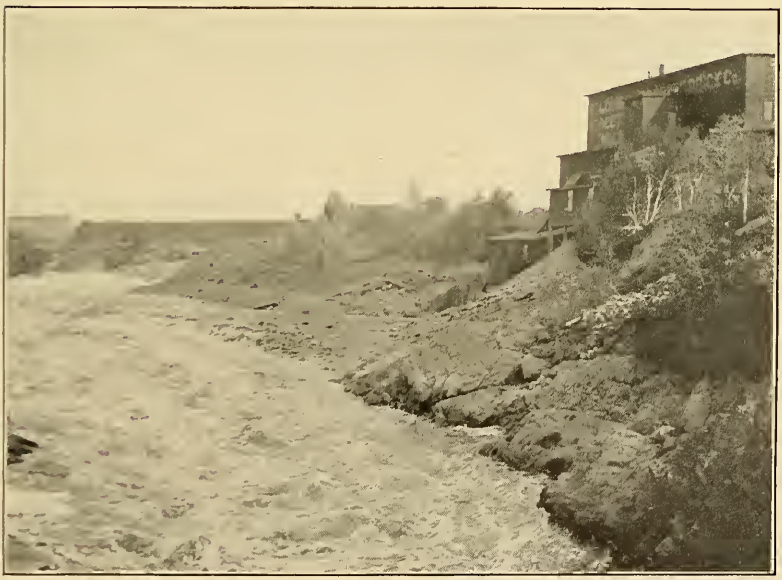
At St. Anthony Falls, the Mississippi descends 50 ft. in a short distance.

Besides the falls on the larger streams of the state there are many beautiful falls on the small streams, of which Minnehaha Falls, Kettle River Falls, Minneopa Falls are most widely known. Many beautiful falls are found on the small streams and rivulets flowing into Lake Superior.

The streams of Minnesota are naturally favorable for cheap power development. The amount of power which may be developed will depend, to quite a large extent, upon the utilization of all available storage sites for the storage of flood waters. The following summary of developed and undeveloped waterpower of the state of Minnesota is contained in the report of the State Drainage Commission for the years 1909 and 1910:



Log Sluice around Big Falls on Pigeon River. Pigeon River falls 135 feet at this point.



Great Northern Power Company. Big Dam on the St. Louis River near Carlton, Minn., where a head of 375 feet is developed.

Drainage Basin.	Theoretical Horse-Power.	Developed Horse-Power.	Undeveloped Horse-Power.
Mississippi River	234 000	60 000	173 700
Minnesota River	8 300	600	7 700
Minnesota River Trib	9 500	2 400	7 100
St. Croix River	28 000	4 500	23 500
St. Croix River Trib	4 900	1 200	3 700
Other Mississippi Trib. above Minnesota River	26 300	2 000	24 300
Other Mississippi Trib. below Minnesota River	28 800	5 100	23 700
Red River (including Ottertail)	30,400	1 100	29 300
Red River Trib	28 300	1 900	26 400
Rainy River	22 000	12 000	10 000
Rainy River Trib	61 800		61 800
Lake Superior Trib. east of Duluth	20 700		20 700
Lake Superior Trib. west of Duluth	50 700	22 000	28 700
	553 700	113 100	440 600

This summary places the total available power on the streams of the state at 553 700 horse-power. These figures are based on the ordinary low-water flow, under natural conditions. By utilizing all available storage, it is quite probable that this estimate would be increased at least 33 per cent. for ordinary years, years such as 1909. This would bring the available water-power of the streams of the state up to 830 000 horse-power. The years 1910 and 1911 have been extraordinarily dry years. The total annual precipitation in the year 1910 was less than half the average mean annual precipitation in the state for a period of twenty-five years prior to 1910. Consequently, estimates based on the flow of streams under conditions that prevailed in these dry years would be worthless.

The federal government has constructed five large storage reservoirs on the head waters of the Mississippi, known as the "Winnibigoshish," the "Leach Lake," "Pokegama," "Sandy Lake" and "Pine River" reservoirs. The total capacity of these reservoirs is 93 000 000 000 cu. ft. or sufficient water to give a flow of 3 000 second-feet for a period of one year. Owing to the fact that these reservoirs are from three hundred to four hundred miles above the principal developed water-powers in the Mississippi, and also to the fact that there is so much uncertainty and irregularity as to the rainfall in the drainage basin of these reservoirs, it is not practicable to get the results that could be secured were they located within easy reach of where the water is required for power purposes.

The State Drainage Commission, in coöperation with the United States Geological Survey, has for the past three years been making a water resources investigation of the state. These investigations and surveys are nearly completed. A complete report of these investigations will be ready for distribution by January 1, 1913. This report will show that it is entirely feasible to store up for use, when needed, the flood waters of many of the streams of the state, in addition to the storage reservoirs now in operation. By a judicious use of these reservoirs, the flood waters of the streams upon which they are located can be controlled and danger of damages from overflows largely decreased.

Forty-two billion cubic feet can be stored in Red Lake, several billion feet in Ottertail Lake and a few billion feet on head waters of Wild Rice River. With these storage sites utilized to their fullest capacity, a considerable amount of the flood waters of these streams could be stored up for use in times of low water instead of being allowed to swell the volume of the Red River of the North above the danger point. Storage reservoirs are also feasible to a limited extent on the Minnesota River. The federal government has just completed the plans and estimates for a large storage reservoir at Lac Qui Parle. This proposed reservoir will have a storage capacity of 39 000-000 000 cu. ft. Its construction would go far towards preventing the overflow of this stream, which has caused millions of dollars in damages during the past ten years.

A head of two feet on Rainy Lake would hold back twenty billion cubic feet of water; this storage would solve the problem of securing a nearly uniform flow at International Falls. Small storage reservoirs are feasible on some of the streams flowing into Lake Superior. Here a little water gives a lot of power with a head of 375 ft., such as we find at the Great Northern power plant at Thomson. A cubic foot of water per second will develop 34.1 horse-power.

The water resources of the state are her richest heritage; her greatest blessing. The proper conservation and control of the waters of the state are, therefore, problems of greatest importance, which demand the best thought and most candid consideration of all her citizens.

[NOTE. — Discussion of this paper is invited, to be received by Fred. Brooks, Secretary, 31 Milk Street, Boston, by July 15, 1912, for publication in a subsequent number of the JOURNAL.]

REGULATION OF INDUSTRIES BY GOVERNMENTAL SUPERVISION.

By J. H. G. Wolf, Member of the Technical Society of the Pacific Coast.

[Presented at the meeting of the Pacific Association of Scientific Societies, Technical Society Pacific Coast Section, Stanford University, April 6, 1912.]

Few observers have failed to see the change in social conditions in the past decade in the United States and in the world at large. Sociology, broadly considered, is defined as the study of the forces and phenomena of social life; government and economics are probably its most important considerations. Changes in governments are reflected almost immediately in changes in the economic status of the people; at times change brings on better conditions, and again worse conditions. Unstable government, whatever its form, provokes the worst situations. To inquire into the influence of government over economics or to the extent to which the body politic influences the economic is the purpose of the following.

Political Change.

Great changes in the universal political map have occurred in this decade. In Europe, France threw off the domination of the Vatican which had overshadowed its political and social life for a century, while Spain, where the phenomenon was all the more extraordinary, did likewise; Portugal witnessed first the assassination of a king and a crown prince, and then, shortly thereafter, the overthrow of a centuries-old monarchy in favor of a republic, which is as yet unstable. Finland was absorbed by Russia, but in turn the power of the Russian absolute monarchy, one of the few remaining, but the greatest of them all, was broken by the establishment of a national law-making body, — the Duma. Turkey saw the overthrow in a night of a sultan who had ruled as a tyrannical despot for thirty years, and the establishment of a more enlightened constitutional monarchy. Austria grasped several of the Balkan states, whose independent sovereignty had always been more or less uncertain, yet necessary for the equilibrium of the European states. In Africa the partition of the soil among the European powers, with the exception of Abyssinia and Liberia, was completed. England, at the cost

of a billion, conquered the Boers to insure to British stockholders the prize from the Transvaal mines, and thus, too, was born United South Africa. Morocco presented the periodical problem; Tripoli, after a century of domination to the star and scimitar of the Turk, is passing to the power of the Christian cross; the Congo was further exploited and partitioned. In Asia, Persia became the vassal of Russia and England; the United States gave to the Philippines a form of representative government, a thing unknown to the Malay, after four centuries of exploitation by Spain. Japan overthrew Russia in the Far East and forthwith absorbed a nation, Korea; and at this hour there is occurring the birth-struggle of a new republic, China, which witnesses 400 000 000 people of one race in the transition from a monarchial to a representative form of government, and there is none who can say what the outcome will be. In the Americas critical changes, owing to the Monroe Doctrine, have been less conspicuous but have been fraught with great significance. Cuba assumed autonomous government under paternal protection. Brazil, the decade previous, threw off its monarchy to become a republic. Mexico, of vast and latent wealth, is in the throes of revolution, the results of which in time as well as consequence are uncertain. Colombia lost a state, Panama, a mere pawn in the international game of chess, but the act opened the way for the United States to link, under desirable conditions, the Atlantic with the Pacific oceans, which accomplishment will change the commercial map of the world, and the effects of which will be as far-reaching as when the Suez Canal opened the new route to the Indies.

With the United States the epochal point was coincident with our stepping into the Cuban situation, which led to relieving Spain of her insular possessions and our taking thereupon a leading position as a world's power. Following closely upon this event, the presidency passed to one who became known, laconically and fitly, as the Strenuous One, a most striking national figure,— Theodore Roosevelt. By and through him more power has been centralized in the federal government in Washington than had ever been brought before into central control. His excusers say this was the evolution of the times, — it was because of the enormous development of our natural resources on such stupendous lines; his accusers say it was because of his indomitable will, coupled with the love of exercise of personal power. Be that as it may: the mighty Civil War of fifty years ago was fought with less provocation for infringement upon the states'

rights than was offered by the federal government between 1902–1909.

Armaments of nations have doubled and tripled in weight and power in this decade; battleships have given way to dreadnaughts, and ere these have been launched have come the super-dreadnaughts — and the end is not yet.

Socialism.

Socialism is defined as a theory of civil polity that aims to secure the reconstruction of society, increase of wealth and a more equal distribution of the products of labor through public collective ownership of land and capital. If the intervention of the federal power in business affairs generally (one of the most noticeable phases of social changes in America) be a step in the advance of true socialism, its progress will not be seriously fought. Socialism in its practical application, however, seems merely to be a protest against the present order of things, that is, destructive without being constructive. The boy at play does not like the toy-house his father has built for him with infinite care and patience, and with a sweep of the hand he lays it low; but, is he able to build another, the one he imagines he would like? Is he able to construct at all? Most men who profess socialism are unable either to reconstruct that which they would tear down, or to understand clearly that against which they inveigh.

Necessary Regulation.

That some form of supervision and regulation by the central government of corporations that do an interstate business, from the character of their activities, is wise and necessary, cannot be gainsaid, but the degree to which it is necessary and the form it shall take are involved questions; likewise, that supervision and regulation of public service corporations in a particular state by the state government is necessary, is equally true. The courts, both federal and state, have uniformly held that where a corporation exercises quasi-public functions, it should be allowed to fix rates sufficiently high to return a reasonable income on its investment, and in their decisions have frequently fixed the rate. If a corporation receives such consideration by the courts, the act of itself tends to fix a market value to its securities; there is all the more reason, then, why such corporation, both from public policy and for the protection of the minority stockholders, should have its affairs scrutinized by a state commission, or by other

properly constituted state authority. The federal power, however, should not impinge upon domestic affairs within a state and it is against this tendency that much criticism is leveled. The ideals of socialism can be obtained probably as effectively with less assumption of power by the federal authority; action by the latter tends to uniformity, but it is a serious question whether from the greatly varying conditions in the several states, uniformity makes for equal justice. A province distinctly federal is the one of the regulation of the interstate railroads.

Bigness Not a Crime.

The business of interstate transportation has grown to such proportions that a single railroad company was recently enabled to finance the expenditure of $100 000 000 to construct a new terminal, — the Pennsylvania entering New York City, — a stupendous amount of money, and a larger sum than was required to run the United States government for a year during the period before the Civil War. But mere bigness is no crime, — the bigness evidenced by the size of the great railway corporations; it is the result largely of the growth of situations incident to the development of our resources and to the natural increase in population. Traffic density, too, has doubled and tripled, and will continue to increase without exertion on the part of the railroads themselves as the density of population grows. It is no crime to build up a magnificent railway system; economical transportation well spread is the basis of material progress and a reasonable cost of living; the blood of our commercial life flows through these arteries. The crime against society begins when the railroad, through the power of the vast capital it commands, buys up, for example, first, the coal mines along its line; then, the coal lands adjacent; then, the iron mines; then, the available timber lands; and finally, the competing water transportation. The illustration has been carried beyond practical limits, but not beyond the limit that some captains of finance would carry their operations if permitted.

Where Crime Begins.

That the above process of pyramiding, so-called, of interests somewhat on the above lines was not unusual, was illustrated by a conspicuous example, when the late E. H. Harriman, a few years ago, then controlling the Union Pacific Railway, caused to be issued upon that system some $200 000 000 new bonds, and

with a part of the new money bought control of the Chicago & Alton Railroad, then bonded the latter to its capacity, and proceeded to buy the control of, or a substantial interest in, numerous other railways. The activities of the Department of Justice stopped these interesting absorptions. Secret rebating is distinctly criminal. Is there reason to inveigh against such practices? It does not take a political economist to point out the end to which such practices would lead the country. The railways must be kept to transportation interests, and on fair competitive bases, if the welfare of all is to be subserved.

Politics.

If the intervention of the federal power has become necessary because of the methods and practices of some corporations, referring particularly to monopolies, which, in turn, derive their power essentially from the law, it is manifestly idle to rail against mere forms of business, or mere bigness of operations. Remedies should be addressed directly to the cause; assaults in intemperate language or on baseless assumptions of corruption generally upon all vested interests are a serious menace to enduring government; they are the fuel to the fires of anarchy that are always smoldering in every community. Regulate and supervise with intelligence and with an understanding of the problem, clean the political Augean stables so that men of probity, ability and character shall sit in the halls of Congress and legislate wisely, fearlessly and without corruption; then the problem will have been adequately attacked. To countenance men buying their way into the United States Senate, which no small part of the body itself appears to do (for they sit in judgment upon their own members), is not scandal but crime; not an offense against mere morals, but a menace to the security of order and government that promotes a suspicion against the whole fabric of the political body.

Bureau Activities.

Coincident with the assumption of larger powers by the federal government, there have come forms of regulation and supervision over general industries by the various departments that have often created unnecessary hardships and provoked bitter animosities. This refers particularly to bureau regulations over affairs in the great West by central officials who frequently have never been beyond the Ohio River, and who have no sympathies with or understanding of the problems incident to the

development of the resouces of the western empire. The regulations promulgated by the Land Office have for a quarter of a century provoked ridicule, and the business administration has been of such erratic character that the courts have been staggered with the problem of bringing order out of chaos. Meanwhile the activities of the strong, when corruptly inclined, have separated from the public domain much that is valuable. The bureau that has created the greatest animosities and the administration of which has created distrust on the part of careful observers is the Forestry Bureau. No thinking man has failed to see the wisdom of establishing the service, nor has failed to commend its avowed purposes, but it would seem that its guidance so far has been intrusted to an unfortunate degree to zealots and faddists with theories, who lack sound doctrine and good business experience. The bureau has had, of course, the problems that arise in new situations and incident to organizing a new department, yet this cannot excuse all of its frequently ill-advised activities and rulings. As specific examples are of more value in illustration than generalities, the following incident may be quoted:

Some years ago the writer was building a mill for a mining camp on the desert in a neighboring state. The desert ranges are covered with a sparse growth of stunted piñon pine and juniper; between the ranges are flat valleys, six to eight miles wide, containing large alkali flats and sinks, over which cattle and wild horses feed; at the mouth of each of the canyons, which discharges a small stream heading in the range, there is usually a stock ranch. The sole industry of the country is mining, and incidentally some cattle raising; agriculture on a commercial scale is impracticable because of the climate, for fruits and grain will not develop until late in the fall and then only in sheltered spots at the mouths of the canyons. The elevation above sea of the flats is some 5 500 ft.

There was no power but steam available to run the mill under construction, and, owing to the conditions, the great money panic being on, much depended upon getting the plant going. The Forest Service had extended its benign arm over this particular range some time previously, and called it a " National Forest." The local officials of the bureau set a price of 50 cents per cord stumpage for cord wood, which was accepted by the mill, and when we were ready to cut, made a contract for 1 000 cords at that price, to be cut in lots of 500 cords each. The first lot was obtained, but when the second lot was wanted the Bureau in Washington decided to increase the price to $2 a cord for

stumpage, and proceeded to repudiate the contract the supervisor had made. The action was summary, but the mill refused to accept the ruling, and the protest that went up from the camp finally reached Washington, whereupon an official was sent out to adjust matters. A town meeting was called the night he arrived, and the young man went away much better informed on desert conditions than he had come. His main defense was that the trees were needed on the ranges to conserve the stream flow for the agricultural interests in the valley, and that if a stiff price were put upon the timber, less cutting would be done! It is one of the tenets of a sect in India that we gain in riches by reducing our wants just as surely and more easily than by slaving to increase our resources; Brahmin philosophy is what this forester would prescribe for a few struggling miners in a very bad situation, in order to conserve interests that did not exist! Desert population is sparser than the timber growths in the ranges, and is migratory at its best, yet here was a conservation enthusiast who wished to deprive a handful of hardy men of the means of proving their mines by imposing onerous conditions upon the temporary use of a national resource in the interests of another branch of industry that could not exist, even if the soil and conditions permitted, without the markets afforded by the miner. The mill won its case; the following year electric power was brought into the camp, and it has pounded out ore continuously since.

Regulation with Understanding.

The severest criticism against regulation and supervision, broadly considered, is the spirit in which it is proposed, and the want of discrimination and judgment used in administering it. It seems that to the official who regulates, and to the country lawyer who legislates, the word " corporation " suggests a hungry grasping power with intent only to tyrannize over the weak and helpless, — the picture of the monster labeled " the trusts," and the helpless labeled " the common people " in the Hearst papers. In regulating, no distinction is made between a corporation capitalized at millions, founded upon a monopoly and doing a nation-wide business, or a public service corporation constructed upon a public utility and allowed a fixed income by law, and that of merely a private corporation capitalized at a few thousand dollars, doing a nominal business and frequently only development work. Twenty or thirty years ago most private business concerns were conducted in the partnership form; to-day this is

practically in disuse; instead is the private company receiving a corporate existence from the state, but having no relations with the public welfare other than to create industry and provide employment for the masses. Agitation against this class of business because of its corporate form is unfortunate, to say the least; it is distinctly against public policy; yet what legislator stops to make proper distinctions when proposing some new employers' liability law, or some new tax upon franchise rights, or proposing new corporate license fees?

The writer's family operated for years a coal mine in southern Illinois, which, while not a large mine, producing some 500 tons per day, represented a substantial investment. For years the competitive conditions were such that the plant barely made interest on the investment, yet whenever the periodical labor question came up, the owners of these small plants were contemptuously referred to as the "coal barons," the "robber barons" who were wringing unearned sweat from Labor's brow; while in reality the company's struggle for existence was often a desperate one. All the while the people, the consumers, were getting coal cheaper than the industrial conditions warranted. There are many situations where a private corporation is more a public benefactor than otherwise, and the operations of such companies should be fostered by the law, not hindered.

Incentive for Private Operations.

As has been indicated before, the officials and legislators proposing and fixing regulations should be men of breadth, capacity and men of affairs, for vast interests are often at stake. The great West was won by men of faith and courage, pioneers who were not afraid with their lives, men of energy, but with meager capital, who grasped the opportunities to develop the natural resources; in their paths to-day the erstwhile arid plains are giving homes to thousands, and latent wealth has been put to work. Would the metals, iron and copper, and coal, the staples of our manufacturing industries, be as cheap to-day if the incentive to discovery and exploitation of the mines had not been held out? or if narrow restrictions had choked off development in the early days of the republic? Is it likely that the wonderful oil fields of California, opened in the past few years, would have been discovered, at least at this period, if petty restrictions had hedged about operations? Would California be taking the lead in the world's production of crude petroleum? Would every

ship's bottom that traverses the Pacific from Panama to Alaska, and every train that hauls a ton of freight on the Pacific slope, be enjoying the munificent benefits of cheap and abundant liquid fuel if the driller had not had the incentive to prosecute the expensive research work of years, which finally led to the discovery of the Lakeview Well and the attendant heavy-flowing wells of the West Side Fields of the San Joaquin Valley? Is it time to choke off individual effort? The man is as much a pioneer to-day who develops a new manufacturing process, or makes a new machine that will cheapen the cost of staples, as the man who won the West. By encouraging the initiative, by fostering the independent, employment for more men is created, industry for capital to exploit is made, and true progress is the better realized. The complaint has gone widely that engineers to-day are underpaid, that work is scarcer and opportunities are fewer. Who and what create the conditions which make jobs? Employment is from two sources: public and private. While the former is the easier to obtain and is often more continuous for a few, the latter is the larger and more remunerative field. Large capital, which is a good employer, can generally take care of itself; it is small capital that in the end provides the most work, and which should receive the most consideration and encouragement, not the bludgeon.

Paternalism.

The history of nations shows that the more men are hedged with central power or control or supervision, the fewer become the opportunities of the individual, and the more the social conditions gravitate to the situation that exists in Europe at this time, particularly in England, where class distinctions are acute, where there is and can be no hope for the underclasses, where serfdom to all practical effects exists as surely as it ever did under the feudal state. It is the judgment of the best thinkers that the social conditions and the state of the development of the natural resources in the United States at this time do not warrant paternalism on the part of the government. The danger in extinguishing individual effort is the more serious because of the entrenching of power in monopolies under paternalism. The bureau official smugly tells us that the water power business in California is no business for the small man — meaning small capital. It very soon becomes no business for small capital — individual effort — if regulations are to be promulgated which make it possible only for giant corporations to enjoy the privileges of

water and power rights. In the methods used, regulations professedly in the interests of the masses are in fact making more tight the bonds of privileged monopoly upon priceless rights, — by making conditions so onerous that private capital, or the individual effort, cannot take up a right or engage in a business, and monopoly smirks at the cleverness of those regulating. Power grows upon the thing it feeds; surround it with the conditions it wants, that is, exclude opportunity from others, and you have the ideal situation for the propagation of the thing fought,— monopoly. If example were needed to emphasize this fact, we need only refer to the restrictions imposed in the new public utilities act of this state upon the financing of new operations of public character. The feeble and perfunctory opposition only, exhibited by the public service corporations at the hearings in Sacramento, when the bill was being shaped, attests only too plainly their satisfaction over the outcome — the statute as it is — a monument to progressive legislation!

Summary.

Political changes and economical changes have been traced: to say that there is a direct relation between the universal political unrest, exhibited by the profound changes in governments, and the economic change and unrest is quite allowable. War makes for economic waste, even though it be followed in instances by commercial prosperity, and the waste incident to keeping prepared for war on the plea, " to preserve peace," is a criminally foolish one, and attests the true status of our civilization. It is not to be wondered at that the cost of living has gone up, ever up, not only in the United States, but throughout the world; governmental regulation of business is probably a phase in the struggle to combat these conditions. To be successful it must be orderly and wisely administered, fostering wise use and prohibiting abuse; it must encourage and not discourage, must strike at the root and not shoot in the air.

[Note. — Discussion of this paper is invited, to be received by Fred. Brooks, Secretary, 31 Milk Street, Boston, by July 15, 1912, for publication in a subsequent number of the Journal.]

ANNUAL ADDRESS.

By Frederick W. C. Whyte, President of the Montana Society of Engineers.

[Read before the Society at its Twenty-Fifth Annual Meeting, held at Anaconda, Mont., April 13, 1912.]

Members of the Society and Gentlemen:

Once more the date of the annual gathering of the members of the Montana Society of Engineers has rolled around and we have had the pleasure of renewing acquaintances and exchanging ideas with our old friends and brother members.

The Society having been organized in July, 1887, this is the twenty-fifth annual meeting, our silver anniversary, and we have reason to be proud of the fact that we are in a sound and healthy condition. The report presented by our Secretary earlier in the day was most gratifying to all of us, showing as it did a strong membership and a satisfactory condition in the treasury. The following membership statement shows the present membership as compared with that at our last annual meeting:

	1911.	1912.
Active	158	175
Associate		1
Corresponding	52	42
Honorary	2	2
Total membership	212	220

During the year the Society had several instructive meetings in its rooms in Butte, and some very interesting matters were discussed. Some of the meetings were well attended, others not so well so, and I would fain impress on some of our members who have not acquired the habit of attending these monthly meetings, yet could conveniently do so, that it would be a good and desirable habit to acquire, and that a larger attendance at these meetings would not only be a benefit to them individually, but to the Society as a whole. It is not necessary for any member to wait to be asked to present a paper at any of these meetings; on the contrary, should any member wish to present a paper at any time or open a discussion on any interesting topic, I can assure him that the other members will be very pleased to have

him do so, and if he will notify the Secretary of his intention, the other members of the Society will be advised, so as to insure, if possible, a large attendance.

Following out the duty imposed upon me, as retiring President of the Society, by the constitution and the strictly adhered-to practice of past years, it falls to my lot at this time to present to you a summary of the engineering progress in the Treasure State during the year 1911. Although the year 1911 will not be recorded in history as one of the more prosperous years from a business standpoint, owing to the slow recovery of the country generally from the panic of a few years ago, I find upon investigating the amount of work performed by engineers in this state during the year that it is well up to the average in quantity and importance, and that I can only touch briefly on the more important features of the same. I am appreciative of the fact that the change in our Constitution which was made last year, whereby the annual meeting was changed from January to April, has made it easier for me to get the necessary data together than it has been in the past for my predecessors, and I find myself wondering how the ex-presidents of the Society ever contrived to prepare the papers they did, so early in January, and to cover so much material and so large a territory.

Montana is to be congratulated upon its showing of new work accomplished during the past year as it proves the abiding faith that her stalwart citizens have in their state, not to speak of the faith of the necessary financial backers in other states and countries. With her enormous areas of fertile land, ready on the magic touch of the plow and the application of water to produce sustenance for many times her population; not to speak of wealth for the owners, and her inexhaustible resources of minerals to be extracted, transported, reduced and disposed of,—is it any wonder that each year we chronicle the development of water powers, the building of reservoirs and drainage canals, the extension and improvement of railways and the various other engineering work which necessarily accompanies the same. We have indeed a state to be proud of, and as members of the Montana Society of Engineers we have reason to be proud of the fact that during the twenty-five years of the existence of the Society the greatest part of the wonderful development of our state and most of the larger engineering achievements have been accomplished by members of the Society.

In getting together the data for this report I have necessarily had to call upon the various engineers and others at the heads of

the different organizations for the details regarding the same, and I hereby express my thanks to one and all of them for the willing response given to my requests. In order to avoid encroaching too much on your time and patience, I asked in each instance for a short summary of the work performed under their jurisdiction, and as many of them complied in this respect I, in most cases, give you their verbatim reports.

United States Surveyor-General Office, Helena.

Through the courtesy of Surveyor-General J. G. Locke, at Helena, I have the following data regarding the work of his office during the past year:

"There will soon be open for entry in Montana 6 107 000 acres of land. Of this amount, 2 104 000 acres have been surveyed during the past year, 1911, 80 800 of which was done under the old contract system and 2 023 200 acres under the new system, whereby the surveys are carried on by civil service employees, working on a salary, and under the direct supervision of Surveyor-General Locke and Assistant Supervisor of Surveys J. Scott Harrison. The remaining 4 003 000 acres were surveyed, or practically surveyed, in 1909 and 1910, but the working up of returns and the final acceptance of the work has been delayed for various reasons, chief of which has been the failure of contractors to make such corrections as were necessary before the work could be accepted, forest fires which drove deputies from the field in the western part of the state in 1910, the inability to secure sufficient examiners to properly check the work after it had been done and the vast amount of detail involved in the change from the contract system to the direct system.

"Of the 6 107 000 acres on which the field work of survey has been completed, the field notes on 1 838 544 acres have been worked up in the Surveyor-General's office, the work approved and forwarded to the Commissioner of the General Land Office, where it is awaiting his acceptance. It is believed that all of this amount will be accepted by April and the land thrown open to entry.

"Of the balance of 4 268 456 acres, the notes are being platted and checked, and as rapidly as this can be done the work will be approved by the Surveyor-General and forwarded to Washington for final acceptance. It is hoped that most of it can thus be disposed of by July 1. In some cases corrections of the work in the field will be found necessary and it probably cannot be disposed of finally until next fall, or early winter.

"The cost of the field work for the 2 023 000 acres surveyed in 1911 under the direct system is approximately three and one-tenth cents per acre. Had it been done under the old system by contract it would have cost approximately seven cents per acre.

This fact, coupled with the facts that under the direct system practically all of the corners are iron posts, and cannot be so easily destroyed or moved, that under the direct system there is eliminated the heavy expense and long delay of examinations by an inspector, and the more important fact that the work is of a far better quality, because the deputy has no incentive to slight details for the sake of speed and profit, makes it patent that it was a serious mistake that such a system was not inaugurated years ago.

"Other data recently compiled in the Surveyor-General's office show that there are yet 27 000 000 acres of unsurveyed land in Montana, 12 000 000 of which are in forest reserves, and not within the land grant of the Northern Pacific Railway, and for which no provision for survey is now made by law.

"In addition to the foregoing, there was surveyed for patent, under the direction of the Surveyor-General's office, and approved, a total of 244 mining claims. There were also surveyed, by metes and bounds, and approved by the same office, 33 homesteads in forest reserves, with areas varying from 20 to 160 acres each."

Carey Land Act Projects.

The year 1911 was a comparatively inactive one so far as work under this act in the State of Montana is concerned. Through the courtesy of Mr. A. W. Mahon, state engineer, I have the following report concerning the same:

"Very little has been done in the way of construction during the past year under the supervision of this office. Among the Carey Land Act projects the Billings Land and Irrigation Company have confined their work to cleaning and widening their canal and building a reinforced concrete head gate at their intake from the Yellowstone River.

"The Big Timber Project has had virtually no construction this year, but is contemplating considerable work in the near future which, under the present requirements of this office, will require permanent structures instead of permitting the class of structure erected in the past.

"The Conrad Project has been in the hands of a receiver but was taken up by a syndicate and work begun last July, wherein one hundred men, in eleven parties, were in the field, comprising the engineer corps together with ten men in the office, working up the topography and making standard and special plans for the new work. Upwards of $400 000 on construction and engineering has been expended since July, 1911, and all structures upon canals or laterals having over ten second-feet capacity are required to be permanent in their design and construction. Agreeable to the requirements of this office, the Lake Frances reservoir dam, impounding 112 000 acre-feet of water, is now being repaired and strengthened. Another structure which this

project has completed surveys for and is now making plans for, is a dam in the Birch Creek canyon in the main range of the Rockies, which will have a maximum height of 160 ft. and will cost approximately $400 000 and will impound only approximately 30 000 acre-feet of water, but this is necessary to complete the water supply for the project, which comprises about 117 000 acres of land.

"The Ruby River Project is not yet operating, but contemplates a reservoir dam of rock fill, concrete core wall and earth embankment 125 ft. high.

"The Flatwillow Project is not yet operating, but is planning a 97 ft. earth dam. No plan has as yet been submitted to this office.

"Other projects are being worked out, but no actual construction is contemplated in the near future.

"Stream Gaging is being carried on by this office, in conjunction with the United States General Survey, but owing to the limited amount of money appropriated by the state for the purpose, our scope of usefulness is limited. . . . The proposed report will be as accurate as it is possible to make it with the means we have to work with, and as it will be of interest, from a statistical point, to every engineer in the state who has occasion to make hydraulic investigations in his practice, we ask that he take a little interest in the work at this time and give us any data he may have at his disposal along these lines."

Railways.

Mr. F. J. Taylor, division engineer at Livingston, reports regarding the work performed by the Northern Pacific Railway during the year as follows:

"The work done consisted principally of improvements of the main line, including the following:

"Fourteen hundred ft. of steel bridges and 700 ft. of reinforced concrete trestles, replacing temporary timber bridges; 250 miles of track ballasted. A branch line has been completed, 55 miles long, running from Glendive northeasterly along the Yellowstone River. The Camp Creek Railway has built 15 miles of line running southerly from a junction with the Northern Pacific at Manhattan, in the Gallatin Valley."

Mr. P. S. Hervin, resident engineer at Great Falls, reports as follows regarding the work performed by the Great Northern Railway during the year:

"*Sun River Line.* — This is a branch line from Vaughn to Augusta, 40 miles long, through the Sun River Valley. The road is located on the north side of the river from Vaughn to Sun

River, where it crosses the Sun River and runs on the south side through Fort Shaw, Simms and Riebeling and crosses the south fork of Sun River near Augusta.

"The grading of this line was completed during the summer and track laid from Vaughn to the crossing of Sun River, a distance of 9 miles. At this point there is a bridge across the Sun River 1 200 ft. long, consisting of one Howe Truss span 150 ft. long and three Howe Truss spans 100 ft. long. It has pile approaches on both ends. The bridge is now under construction and will be completed by the latter part of March, and then, as soon as weather permits, tracklaying will be resumed. We expect to complete this line by the early part of summer.

"The construction of this line is comparatively light, being mostly team work, but on account of running through an irrigated country a large number of small openings have to be put in under the roadbed for irrigating and drainage. For this purpose cast-iron pipes were used, varying in size from 12 to 36 in. in diameter. There are also a number of pile and truss bridges on this line where it crosses the creeks and coulees. For the present this line will end at Augusta.

"*Moccasin to Lewiston Line.* — This line has been located from Moccasin, on the Billings Line, to Lewiston, a distance of 32 miles. Contract was let to the Siems-Carey Company of St. Paul, and construction was started in the month of December.

"The construction of this line is comparatively heavy, there being considerable steam shovel work near the crossing of the Judith River. Across this stream will be constructed a steel bridge 1 880 ft. long and 100 ft. high. Concrete foundations for this bridge will be started as soon as the weather permits, and it is expected to complete the line into Lewiston before fall."

Mr. C. A. Lemmon, chief engineer, reports as follows regarding the work performed by the Butte, Anaconda & Pacific Railway during the year:

"The only work worthy of note was the construction of the Tuolumne ore spur at Butte. This spur is approximately one mile in length and includes a bridge containing 320 000 F. B. M. of lumber. The grading was comparatively light, there being but 20 000 cu. yd. of excavation in all.

"Preliminary lines were run for the proposed extension of our main line to the Georgetown Mining District, and the final location was commenced December 4. The location is now completed and construction under way. The quantities will be approximately as follows: 200 000 cu. yd. earth excavation, 100 000 cu. yd. loose rock and 40 000 cu. yd. solid rock. The extension will be approximately $16\frac{1}{2}$ miles in length, in addition to which there will be about $4\frac{1}{2}$ miles of new wagon road to build in order to replace that destroyed by the railway."

Good Roads.

The Good Roads movement is a strictly live issue now in this state and is fast crystallizing into definite form. Owing in a large measure to the insistent clamor of the automobilists of the state to the effect that there was much room for improvement in our state highways, the people generally, and those in a position to do something for these highways, have at last awakened to the fact that something could be done and should be done to improve the conditions, and also that when it is done it will return the cost many times over. Unfortunately the effort that was made more than a year ago to get concerted action and permanent results by means of legislation was defeated, the Good Roads Bill that was so laboriously and carefully drawn up by the Special Committee having been delayed so long in the House before passage that there was no time left for the Senate to take action on the bill. Every effort should be made to have the same bill, or a similar one, presented to the next legislature and favorable action taken thereon.

Meanwhile in many counties of the state the commissioners have been doing good work in the way of highway improvement. Many of them seem at last to have realized that the old patchwork method of repairing roads is a waste of money and have adopted the method of building a certain amount of permanent road each year, so that in the course of a few years our road system will show material improvement. In the County of Deer Lodge alone fifteen miles of permanent roadway, ballasted with lime rock or gravel, were built last year, in addition to similar work in previous years, and already, as a result of this system, the county is becoming famed for its good roads. If all the other counties in the state would adopt the same plans for road improvement, travel on the roads of the state would soon become a pleasure in place of a risk, as it is in many instances at present.

Very effective work was done during the year by convict labor which was used in building the more expensive pieces of road which the counties individually were financially unable to build. The State Board of Prison Commissioners are entitled to the thanks of all fair-minded men for the good work thus performed in the face of concerted opposition from certain quarters. Mr. Frank Conley, warden of the State Prison, advises me that during the year the convicts built six miles of road in Granite County, about twenty miles in Powell County and about seven miles in Sanders County. Mr. Conley states further as follows: "In the latter county it was solid rock. We moved about 130 000

yd. of rock and 30 000 yd. of dirt, at an expense to Sanders County of less than $10 000. In Granite County we built a piece of road between Drummond and Bearmouth, cutting and avoiding the Flint Creek Hills. In Powell County we built from Deer Lodge to two miles the other side of Garrison, and from the north line of Deer Lodge County to the Quinlan ranch."

It is somewhat of a reflection on our system of handling the roads in our state when individuals feel compelled to build public roads. In Silver Bow County Mr. A. J. Davis, an enthusiastic Good Roads advocate, has earned the gratitude of thousands by rebuilding with his own money the old "eighteen-mile hill" near Pipestone Pass. The old road was practically impassable at times and dangerous at all times, for either farm wagon or automobile, but is now an easy and safe road at all times of the year. Mr. A. E. Hobart gives me the following data concerning this piece of road work:

"This hill is at the head of Blacktail Deer Creek, Nine Mile Canyon, and is the principal road leading from Butte to the Jefferson Valley, crossing the continental divide directly over the 2 500 ft. tunnel of the Chicago, Milwaukee & Puget Sound Railway. The old road was very uneven for the first 800 ft. from the bottom of the hill on the Butte side, with a grade varying from 18 per cent. to 26 per cent. and with a bad sandy approach. The next section consisted of 1 000 ft. of a 15 per cent. grade.

"The new work was commenced about 300 ft. below the sandy approach of the old grade and was constructed on a 13 per cent. grade, keeping to the left of the old grade but crossing the same near the steepest point and swinging to the left along the creek bed, again coming into the old road at a distance of 2 000 ft. up the hill. From this point the old grade was considerably lighter, the roadbed good, and very little work was done with the exception of a point of rocks in a short bend of the road. This was blasted away and the roadbed widened. This 2 000 ft. of new roadbed consisted of 350 cu. yd. of excavation and 2 250 yd. of fill, most of the fill being at the lower end over a side gulch, in which a bridge was built to allow drainage. The roadbed was made 18 ft. in width, with a 4-in. crown and a ditch 3 ft. wide and 18 in. deep on the upper side of the roadbed, 10 in. tile drains being placed at 45 degrees to the roadbed wherever considered necessary. The work was done last fall and the road has been open for travel all winter and greatly used by automobiles and others."

Flathead County has done some very efficient work during the past year in the way of road building, an impetus having been given the subject by the opening of the Glacier National Park.

Mr. P. N. Bernard, secretary of the Kalispell Chamber of Commerce, has furnished me with considerable data concerning what has been done and what is proposed, from which I take the following items of interest:

"Last year a good road was built from Kalispell to the Glacier National Park, a distance of 38 miles, on which Flathead County spent $17 000, the citizens of Kalispell raising $1 500 in cash to aid the enterprise. Fifteen miles of this road is through dense forest, the road having a 40-ft. sky line, all stumps blasted out and removed, and the roadbed plowed and graded 30 ft. wide from ditch to ditch.

"An auto road from Kalispell, via Whitefish north, following along the shore of Stillwater Lakes and Stillwater River to the Lincoln County line on the north, is nearly completed. At the Lincoln County line the road has been taken up by the Commissioners of Lincoln County and pushed through via Eureka, Mont., to Gateway on the International Boundary line. From here the Canadian Government has a fine road to Elko, Fernie, Macleod and through Crow Nest Pass to Alberta. An auto road will be completed this year from Banff Park, on the Canadian Pacific Railway, south through Yellow Head Pass, south to Windemere Lake and then down the Kootenai River to Gateway, Mont., thus giving an international auto road connecting Banff Park, Glacier National Park and Yellowstone National Park.

"The County Commissioners of Flathead County have authorized an appropriation of $7 500 for an auto road from Ronan and Polson on the Flathead Reservation, south of Flathead Lake, passing along the east side of Flathead Lake via Bigfork to Kalispell. This road will run along the water's edge of the lake most of the distance of 35 miles and will be one of the most scenic routes in the northwest. The Flathead Park to Park Association guarantees to raise $7 500 to help build the road, a large part of which is already completed.

"A perfect auto road has been completed by Flathead County along the west side of Flathead County for a distance of 30 miles, paralleling Flathead Lake to the Flathead Reservation, thence south around the south side of Flathead Lake to Polson. From here, via Ronan and Ravalli to Missoula is an auto outlet to Helena and Butte."

Power Companies.

Mr. H. H. Cochrane furnishes me the following information as to the progress during the year by the companies with which he is connected:

"*Madison River Power Company.* — A 50 000-volt transmission line has been built from Ruby to Twin Bridges, a distance of 20 miles. This is an extension of the line previously built

from the Madison plant to Ruby. This new line serves the towns of Alder, Laurin, Sheridan and Twin Bridges. This construction is of a type only recently adopted as a standard by the company. The poles are 45 ft. in length and spaced 300 ft. apart in level country. Where the country is rough or broken, poles are located at the highest points and spans are of irregular length, sometimes being as great as 900 ft. Suspension insulators of three units are used for this voltage. These insulators will stand an electrical test of 150 000 volts when wet, and have an ultimate mechanical strength of 10 000 lb. The conductors are of stranded copper, and protection from lightning is afforded by galvanized steel ground wire strung on the top cross arm and grounded at every pole.

"The substations on this line are of the outdoor type, also recently adopted as a standard by the company for small installations. This substation consists of an outdoor framework made of four poles under which stands a 50 000-volt, 250-kw. 3-phase, self-cooling, outdoor transformer. This is connected to the line through an outdoor airbreak switch located on top of the framework. Its low tension side supplies power to the town through an oil switch, also of the outdoor type. Outdoor electrolytic lightning arrestors are located adjacent to the transformer.

"The elimination of a substation building considerably reduces the cost of the substation and makes it possible to serve towns economically where, previous to the adoption of this type of construction, the expense would have been too great to warrant a substation.

"*Great Falls Electric Properties.* — The old frame car barn which was destroyed by fire in the winter of 1910 was during the last year replaced by a new structure considerably larger than the old one and better adapted to the requirements of the service. The new building is 167 by 88 ft. in plan, is a steel frame building covered with corrugated iron; the floor is of concrete and an ample number of pits is provided for repair work. Shops are provided in one end of the building and these are served by a traveling crane.

"*Montana Reservoir and Irrigation Company.* — The work on the Hebgen Reservoir Dam, located in the upper Madison Canyon near Yellowstone Park, has progressed to a point where one season's more work will complete the dam. The core wall trench was completed to bedrock, approximately 20 ft. below the river bed, entirely across the site, and the concrete core wall completed to an elevation 30 ft. above the river bed. This core wall is backed up by a rock fill on the downstream side and an earth fill on the upstream side. The water has been shut off and is now discharging through the outlet works, which have been completed. The outlet works consist of a 12 ft. pipe laid on bed rock under the dam. On the upstream end of the pipe, and connected thereto, is a concrete gate tower which stands on bedrock and extends up to the same height as the top of the dam, a total height of approximately 80 ft. This gate tower has four

vertical openings or slots 8 ft. wide and extending from top to bottom. These slots are closed by stop logs which are handled by a hoisting apparatus at the top of the tower. By this method an overflow into the tower and through the pipe can be maintained at any elevation and of any desired amount. The tower is heavily reinforced with twisted bars to resist the inward pressure of the surrounding water.

"The construction of the 12-ft. outlet pipe deserves particular mention. This is in effect a wood-lined reinforced concrete pipe. It was constructed by first erecting a steel-banded wood pipe and then enclosing this pipe in concrete. The concrete is made sufficiently thick to withstand, by arch action, the weight of the dam and water by which it will be covered. The steel bands of the wood pipe being imbedded in the concrete, act as a reinforcement to still further increase the strength of the concrete envelope.

"This dam when completed will raise the water 80 ft. above its original level, and will form a storage reservoir having a capacity of fifteen billion cubic feet. Its contour line will be approximately 65 miles in length. The capactiy of this reservoir will be sufficient to store the entire flood of the river during the months of May and June, and distribute this flood evenly throughout the remainder of the year, making the flow below the dam practically uniform for the twelve months."

Mr. M. H. Gerry, Jr., chief engineer and general manager of the United Missouri River Power Company, has furnished the following details of the Hauser Lake dam which was completed last year:

"The Hauser Lake dam was completed in the latter part of last July, but the power plant was not put into regular service until about the first of November. The last section finished was that in the deepest part of the river channel where the bedrock was about 60 ft. below the water level. The contractors on this part of the work were the Foundation Company of New York. They used the pneumatic caisson method and first sank a chain of wooden caissons to bedrock surrounding the area to be covered at the base of the dam. The lower section of these caissons was filled with concrete and became a part of the permanent structure. After the caissons had been sealed together and to bedrock, the interior space formed by the chain of caissons was pumped out and the gravel and other loose material excavated. The concrete of the dam was then placed directly on the bedrock. The following are the dimensions of the completed structure:

"Maximum height of dam from lowest bedrock to top of bridge at elevation 3 640, 129.3 ft.

"Maximum height of spillway crest at elevation 3 621 above lowest bedrock, 110.3 ft.

"Maximum thickness at the base of the dam, 100 ft.

"Normal thickness at base of the dam, 86 ft.

" Thickness at end of O. G. (elevation 3 560), 67.5 ft.
" Over-all width of concrete bridge, 23.5 ft.
" Radius of crest, 21.2 ft.
" Length of dam over all, 720 ft.
" Length of spillway section over all, 491 ft.
" Number of piers supporting bridge, 23.
" Thickness of each pier, 24 in.
" Clear opening between each pair of piers, 18.54 ft.
" Clear spillway opening without stanchions, 445 ft.
" Clear spillway opening with 72 stanchions in place, 407 ft.
" Total masonry in dam (excluding canal walls, sea walls, abutments and power house), 83 000 yd.
" Total Portland cement used in masonry for dam, 125 000 barrels.

" The general contractors for the dam were the Stone & Webster Engineering Corporation of Boston, Mass. The contractors for the deep foundations were the Foundation Company of New York City. The power house, canal, hydraulic works, etc., were built by the company on force account."

Mining.

Mr. B. H. Dunshee, assistant superintendent of the Anaconda Copper Mining Company at Butte, has furnished me with the following interesting data regarding the operations of that company during the year:

" During the year 1911 mining has been active in the various mines of the Anaconda Copper Mining Company. The average number of men employed per day was 8 778. The High Ore and Diamond shafts have reached the 2 800-ft. level and are connected on that level by crosscuts and drifts. A number of other shafts will reach the same level during the present year.

" A number of large exhaust fans have been placed on the various air shafts, with the result that the lower levels are as well ventilated as the upper levels, and in some cases even better. The total capacity of these fans is about 800 000 cu. ft. of air per minute. This, together with the natural ventilation which is sufficient in several of the smaller mines, gives an ample supply of fresh air. The question of sanitation, always an important one, especially in deep mines, has been greatly improved by the introduction of sanitary cars. These cars have given good satisfaction.

" The use of electric power, both directly and indirectly, is increasing each year in mining work. There are at present 36 electric motors underground used for hauling the ore from the stopes to the shafts. There are 15 motors on the surface, used to haul ore from the bins at the shafts to the railroad ore bins, and timber to the framing saws. During the past year three large hoisting engines (Mountain View, Diamond and High Ore) have been equipped with larger cylinders, 32 in. by 72 in., in

order to use compressed air, at 90 lb. pressure, for hoisting, instead of steam. The use of air has been very satisfactory, and it is the intention to change the hoisting engines at the other mines as rapidly as possible. At the present time work is progressing at the Leonard Hoist. The following description of the Butte Hoist Compressor Plant may be interesting:

"The first installation of this plant consists of three electric-driven, cross-compound, variable-capacity, Nordberg compressors, 30 in. and 50 in. by 48 in., of 7 500 cu. ft. of free air capacity each, aggregating 22 500 cu. ft. per minute. These compressors are direct driven by 1 200-h.p. Westinghouse synchronous motors. The proposed complete plant will consist of three additional compressors of 7 500 cu. ft. of free air per minute each, making a total for the six compressors of 45 000 cu. ft. per minute. The amount of air required to operate thirty of the largest hoists in Butte is estimated at 39 000 cu. ft. of free air per minute, compressed to 90 lb. pressure and reheated to 350 degrees fahr. before entering the engine cylinders.

"For reheating the air at each hoist a 50-h.p. return tubular boiler is used which is operated under a pressure of 200 lb. gage. The steam at this pressure, with a temperature of 387 degrees fahr., circulates through a sectional surface heater of special design, 50 in. diameter by 25 ft. high, located near the hoist. For reheating air to 350 degrees a coal supply of approximately $\frac{1}{3}$ lb. per hour per h.p. is used, which produces an increase in volume of air of about 50 per cent.

"For the first installation of three compressors, twenty-four air receivers, 10 ft. diameter by 30 ft. high, are used for storage. These receivers aggregate 56 548 cu. ft., which at 90-lb. gage pressure equals 480 000 ft. of free air at the altitude of Butte. They are connected with the mining air plants so that any excess of air unused by the hoisting plants is passed to the mines for underground use. In addition to these, ten receivers, 10 ft. diameter by 56 ft. 8 in. long, are used in connection with a steel tank 100 ft. diameter by 10 ft. deep, for storage and hydrostatic pressure.

"The said tank is located on the hill 21 ft. 6 in. above the line of main floor of compressor plant, and the hydrostatic pressure receivers are located down the side of the hill at a point where the bottom of the battery of receivers is 199 ft. 6 in. below the bottom of the tank. Thus, with 500 000 gal. of water in the tank, with a depth of 8 ft. 6 in. of water, there is a difference in elevation between bottom of receivers and surface of water in tank of 208 ft., producing a pressure of 90 lb. per square inch on the air of storage receivers at the central station and hoists. The complete installation of hydrostatic receivers will consist of sixteen in number.

"A 42-in. water pipe line connects between the hydrostatic receivers and the tank, having a safety loop at the bottom of the pipe line, with a drop of 25 ft. for the purpose of preventing the air from escaping through the water system to the atmosphere.

An 18-in. air pipe line connects from the top of the hydrostatic receivers to the storage receivers at the central station. A reduction in air pressure from 90 lb. to 82 lb. would cause a flow of 500 000 gal. of water from the large tank to the hydrostatic receivers. Five hundred thousand gallons, or 66 840 cu. ft., of water flowing into the receivers means the displacement of 66 840 cu. ft. of air at 90 lb. pressure, equal to 568 140 cu. ft. of free air at the altitude of Butte, which is equal to about fifteen minutes' average run of thirty of the largest hoists in Butte. Thus, with the compressors idle, the hoists could continue in operation for fifteen minutes to reduce air pressure from 90 to 82 lb. with the hydrostatic system alone, and with the addition of 18 receivers at the central station and 4 at each of 30 hoists, making a total of 138 receivers 10 ft. diameter by 30 ft. high, the 30 hoists could continue to operate for twenty minutes on a reduction of air pressure from 90 to 82 lb., whereas, without the hydrostatic system the hoists could operate only five minutes to produce the same reduction in pressure.

"The theoretical efficiency of hoisting by compressed air, based on practical calculations, with reference to the electric power applied to compressor motors, is as follows:

"Motor efficiency, 95 per cent.; mechanical efficiency of compressors, 90 per cent.; efficiency of compressing air in cylinders of compressors, 83 per cent.; efficiency of hoist, 50 per cent., equal to 35.48 per cent. efficiency without reheat. Increase by reheating, 50 per cent., giving an equivalent of 53.22 per cent., or 1.88 electric h.p., applied to motor to equal 1 h.p. output of hoisting engine.

"At the High Ore mine there have been installed six 7 by 12 Anaconda quintuplex, electric-driven pumps of 600 gal. per minute capacity each, for 1 200 ft. head, three on the 1 200-ft. level and three on the 2 200-ft. level. Each of these pumps is driven by two 150-h.p. motors. These motors are 14-pole, 60-cycle, 3-phase, 2 200-volt induction type, with squirrel cage rotors, 495 rev. per min. at full speed. There are three bearings to each motor. With each pump there is one 300-h.p. starting compensator and one automatic oil circuit breaker with overload and no voltage release. The wiring for the motors is in conduit and made waterproof and as nearly fool proof as modern practice can devise. To connect the motors with the surface lines there were required 6 700-ft. 3-conductor cable ($2\frac{1}{4}$-in. diameter, $7\frac{5}{8}$ lb. per foot). The working pressure on the cable is 2 300 volts. Electrolytic lightning arresters set at 3 000 volts are used to protect the cable and equipment from lightning and line surges. There is a total of 18 electric-driven pumps in the different mines at the present time."

Mr. M. W. Atwater, general superintendent of the Butte and Superior Copper Company, furnishes the following data relative to the operations of that company during the year:

"There were 3 010 ft. of drifts and crosscuts driven, from which 64 000 tons of ore were taken; 160 000 tons of ore were mined and milled. The shaft was not sunk any in 1911, the total depth being 1 625 ft. A direct connected motor-driven air compressor was installed in April, 1911. The capacity is 2 350 cu. ft. of free air per minute, requiring 240 h.p. at motor when working against a pressure of 90 lb."

Mr. George W. Wilson has given me the following data relative to progress in the Corbin District:

"The Boston Corbin Company continue their development work through a vertical shaft which is now down about 1 000 ft., with considerable vein development on the different levels. They contemplate the construction of a concentrator this spring.

"Ore from Wickes the Bluebird is developing through a shaft sunk from the tunnel at a point about 400 ft. below the surface, and is a regular shipper of a good grade of ore. The Corbin Copper is developing along the same lines, viz., following the ore from stations cut in the tunnels. The Robert Emmett has been installing heavy machinery and should continue sinking this month.

"The feature of general engineering interest is that all four of these properties are operated by electric power, obtained from the Missouri River Power Company, transformed to 2 200 volts at the Boston Corbin for use there and at the Corbin Copper, while the Robert Emmett transforms for the Bluebird. These two stations at opposite sides of the district make it possible to secure power at a very low initial cost and mark the end of steam power there."

Coal Mines.

During the year 1911 the coal mines of the state were kept reasonably busy, producing in the neighborhood of 2 900 000 tons of coal, practically the same amount as mined during the preceding year. While no large plants were installed or started during the year, there was considerable additional work done in the various fields and quite an amount of improvement in some of the plants.

In Cascade County the Cottonwood Coal Company installed an additional hoisting engine to take care of the coal from their No. 6 opening, at Stockett; the Brown Coal Company, the Lochray Coal Company and the Sand Coulee Coal Company, all at Sand Coulee, were each engaged in building spur tracks to their respective mines, and tipples for loading the coal; the Lochray Coal Company also building houses for their employees; the Nelson-Jenks Coal Company did considerable experimenting

with a view to using the mine water for boiler purposes, building tanks and house for the chemical treatment of the same, while the Carbon Coal Company installed a rope haulage system from the tipple to the inside of the mine. At Belt the Anaconda Copper Mining Company installed a 66-in. Sirocco fan belted to a 125 h.p. Ames engine for ventilation purposes. This fan is guaranteed to give 100 000 cu. ft. of air per minute with a 7-in. water gage, but has never been tested to its full capacity, sufficient air being produced at half speed to ventilate the mine.

In Choteau County the Havre Electric Light Company leased ground from the state, sank a rock slope through the overlying measures to the coal, built tipple, bunkers and houses for employees and installed a hoist. Near this mine Mr. G. J. Ayers sank a shaft to the vein and Mr. J. R. Alcott sank a slope to the same vein. Near Chinook the Milk River Coal Company built bunkers and installed screens for handling their coal.

In Musselshell County the Roundup Coal Mining Company equipped their mine with electric mining machines and underground haulage, while the Republic Coal Company at Klein have been experimenting with Geo. D. Whitcomb's gasoline motors for their underground haulage. The Keene Coal Company built a spur track from the Milwaukee Railway to their mine and installed tipple, houses, office, etc.

In Carbon Company, at Bear Creek, the Montana Coal and Iron Company installed motor haulage in their mines, electricity being the power employed.

Smelting and Reduction Works.

From Mr. Frank M. Smith, manager of the East Helena plant of the American Smelting and Refining Company I have the following regarding improvements at that plant during the year:

" *New Sampling Mill.* — During the year we have built an entirely new and up-to-date sampling mill of steel and concrete construction throughout. The equipment consists of a pan conveyor into which the ore is unloaded from railroad cars, the pan conveyor discharging the ore on to a traveling grizzly, the oversize from which drops into a No. 5 McCully gyratory crusher. The fine ore which drops through the grizzly and the crushed ore from the crusher drops on to a belt conveyor which carries the ore to the top of the sampling mill. Here it drops into revolving trommel screens, the oversize from the larger screen dropping into a No. 4 McCully gyratory crusher, the discharge from which

is again brought back by belt conveyors to the trommel screens and again sized, the fines from the screens dropping successively into three sets of Davis rolls, viz., 16 in. by 36 in., 14 in. by 30 in., and 12 in. by 20 in.

"At various stages in the process Vezin automatic samplers are installed which cut out fractional parts of the ore for a sample, the final sample being about 1-625th of the whole.

"In connection with this sampling mill, we have also installed an automatic bedding system, which includes a long belt conveyor over the storage bins into which the ore is bedded by a Robins' automatic tripper. The capacity of this mill is about forty tons per hour.

"*Blast Furnace Building.* — To replace our wooden blast-furnace building which was partially destroyed by fire on January 1, 1911, we have built a new steel and concrete building, with a steel incline for the mechanical feed car, operated by a Wellman-Seaver-Morgan electric hoist.

"*Dwight Machines.* — During the past year we have installed one additional Dwight & Lloyd sintering machine, size 42 in. by 264 in., making three of this size machines now in operation. We are installing a fourth machine at the present time and expect to have the same in operation by April 1. This will give us four of the large Dwight machines, size 42 in. by 264 in., and one small machine, size 30 in. by 150 in., the five machines having a total capacity of close to 400 tons per day.

"*New Blower.* — To supplement our blowing engines supplying air to the blast furnaces, we are now installing a Root's No. 8 Rotary Pressure Blower of capacity of about 11 500 cu. ft. of air per minute, which will be operated by an Allis Chalmers 150 h.p. motor."

From Mr. E. P. Mathewson, manager of the Washoe Reduction Works at Anaconda, I have the following regarding that plant and copper metallurgy:

"Referring to progress in copper metallurgy in Montana during the year 1911 I beg to say that a great many experiments have been tried, with a variety of machines, for the concentration of slimes, with more or less success.

"At the Washoe Smelter of the Anaconda Copper Mining Company, the Peck centrifugal concentrator has been tried out and a new machine ordered of stronger construction; we have great hopes of the ultimate success of this machine for this particular work.

"In addition to that, a chemical process, known as the Bradley process, is being installed to extract the copper from the slimes. This plant will be put in operation early in 1912.

"The acid linings for converters have been abandoned and the basic linings (magnesite brick) have been adopted, not only in Montana, but practically throughout the world. It is interesting to note that the first experiments with basic lined copper

converters were tried in Butte at the old Parrott Smelter about the year 1890, and were abandoned on account of cost. In the use of acid linings, the linings had to be renewed every twenty-four hours at least, but with the basic linings a life of about six months is common; in fact, the lining expense of the converter department has been almost eliminated."

Mr. A. E. Wheeler, superintendent of the Boston and Montana Smelter at Great Falls, gives the following interesting information regarding improvement in methods at that smelter:

"First, After a long series of experiments, both as to methods and as to machines used, we have developed and put into operation in one section of our concentrator a new system of concentration, which has so far shown, and promises to continue to show, very marked advance over the concentration as heretofore carried out for Butte ores. The advance is primarily along the line of making greater recoveries in the concentrating process, and of making a cleaner concentrate with consequent cheaper smelting costs. This has been accomplished principally by the use of a classifier which we have developed at this plant after considerable investigation and experiment.

"Second, Like most of the smelting plants of the country, we have adopted basic lined converters. We have not changed the type of our converter, but have merely replaced the old acid lining with magnesite brick lining. We are now building a larger converter than any we have so far used, but this has not been in operation and we can say nothing of the results which will be obtained on it. The point of particular interest in our practice is that on March 9, 1912, the first basic lining which we put into service completed a year's campaign on the original lining. During this time it produced 10 084 tons of copper from a matte averaging not over 40 per cent. copper, and smelted 7 055 tons of ore as flux, and the lining is still in operation and we make no attempt to predict how long it will continue to be in service. This, we believe, is without doubt the world's record both on length of life and on copper produced, or, using what is more probably the correct measure of life, on tons of iron oxidized. Other converters which we have in service are rapidly approaching the record of this first converter.

"Third, We have designed and installed a new type of blast furnace, which is 7 ft. wide at the tuyères, with a sharp but short bosh upward from the tuyères, and a reversed bosh from this lower bosh to the top. The operation of this furnace has shown great improvement over the old type of furnace, and has never shown anything to indicate that it is not correct from a metallurgical point of view. One feature of particular interest is that we have not been obliged to increase the blast pressure in this furnace, but as a matter of fact have run it on a lower blast pressure than our old type of furnace. The furnace has run hotter than any other furnace, and on less fuel, and has exploded

absolutely, in the minds of all who have been connected with the operation of this furnace, the old theory of the penetration of blast due to initial velocity through the tuyères."

In conclusion, I realize that I have failed to record many interesting matters in the foregoing summary. This is accounted for by failure in some instances to answer my inquiries and also by my lack of knowledge as to whom to ask for the necessary information, and not by any lack of desire on my part to record every interesting topic. If I have omitted reference to any special work that any member has performed I regret very much having done so.

I desire to express to the Montana Society of Engineers my sincere appreciation of the honor and privilege afforded me by them of presiding over them for the past fifteen months and also to express the hope that our Society will go on from the great achievements of the past to still greater in the future and will continue to give the best there is in it for the exploitation and upbuilding of our treasured state, — MONTANA.

HIGHWAY MAINTENANCE.

By Robert D. Kneale, Member of the Montana Society of Engineers.

[Read before the Society, April 13, 1912.]

Road preservation is now the most important factor in the question of good roads. It takes but a short time to build a road, but it requires constant vigilance through a long period to maintain that road so as to get the best possible returns on the investment. Among the factors to be considered in locating or constructing a road, due prominence should then be given to the probable cost of maintenance, and as soon as a road is completed it should be turned over to an efficient maintenance organization. It is poor economy to spend thousands for construction and nothing for maintenance. If a railroad were to follow such a plan and discharge the section gang, the roadmaster and the maintenance engineer, it would soon be useless except as a monument to poor judgment. Apparently it is assumed that as long as good roads require less tractive effort than do their poorer tributaries they need less attention. Yet no matter how well or how poorly a road has been constructed, physical, mechanical and chemical agencies immediately begin its destruction, and the better the type of road the greater will be the disappointment over the failure and loss. The road builder is usually blamed for the maintenance failure, and not only is his reputation injured, but a good work is wasted because of ignorance or neglect. The highway engineer then should use every legitimate influence to have his work preserved through proper maintenance. Professional pride in his work, and a possible loss of reputation should be sufficient incentive.

In order to intelligently handle our maintenance problems we should fully consider the various causes of road disintegration, and we may well review some of those causes in this paper. The rapidity with which chemical agents act upon a stone road depends to a considerable extent on the method of construction as well as on the road metal used. The organic acids of fertile regions attack nearly every type of road stone, and the alkalies act upon many of the binders. All ground water circulating through soil containing decomposing vegetable matter carries such acids as carbonic, humic, crenic, apocrenic, ulmic, etc.,

and through their agency rocks containing mineral feldspar are altered into quartz, calcite and clay. These rocks crumble into a fine sand which is carried away by water. Limestones and marbles made up principally of calcite are particularly subject to attack by rainwater impregnated with carbonic acid. The presence of magnesium renders the process slower with dolomite but does not entirely prevent it. Diabases and diorites are least subject to such disintegration. The chemical disintegration of our stone roads, however, is of much less importance than is the physical and the mechanical, and in deciding upon the best metal more weight must be given to the latter agencies.

The most destructive physical agents are frost, ice, attrition, temperature changes, the transporting power of wind and water. Frost suddenly expands the water in the road and not only breaks the bond, but increases the porosity and reduces the stone. Water passing over and through a road carries away much material in solution and in suspension, it gullies the surface, decreases the crown, reduces the grade, renders the surface less waterproof and brings in acids and alkalies. Wind carries away the fine particles, leaving the road without a protecting cushion, and it helps to destroy health and property by transporting the bacteria-laden dust. In some localities abutting property owners, hoping to better living conditions and to increase the value of their property, have built expensive roads only to have them appropriated by through automobile traffic. And the dust from this traffic coated their vegetation, penetrated their houses, polluted the air; and instead of enhancing the value of thier property rendered it almost untenable and unsalable. The dust nuisance is frequently intolerable; but it is economically controllable and it will be given some attention later in this paper. Changing temperature contracts or expands road particles, often at different rates, and so destroys cohesion and increases porosity. And the attrition of falling raindrops wears away the surface.

The most destructive mechanical agents are the impact, friction and penetration of horses' feet; the percussion, abrasion and pneumatic effect of wheels; the crushing due to heavy loads; and the disruption from vegetation.

Some of the more or less effective methods for counteracting these destructive agents are given below: Chemical action may be lessened, and the destruction by frost and water be overcome by keeping the road free from water. This can be accomplished through proper crown, grade, drainage, binder and dragging.

The crown should vary from 1 in 10 for steep dirt roads to 1 in 80 for roads whose binder renders them practically waterproof. The maximum limiting grade depends upon the class of traffic, as well as on the cost of construction and the kind of surface used. Grades for heavy traffic roads should seldom exceed 1 in 20. Shade along the road will reduce extreme temperatures, lessen erosion by the wind, help to stop the dust nuisance by holding the moisture in the road, and make the road a more pleasant thoroughfare for pleasure travel; but air and sunshine are essential to the preservation of the road, and roots frequently cause disruption, therefore from the engineering point of view there is no doubt that a road could be better maintained without trees or shrubbery, or even fences. Transportation of dust by the wind cannot be entirely stopped on the cheaper roads, but it can be greatly reduced by proper dragging with some form of the split log drag. Illinois has given this method a thorough trial during the last four years with the result that many of the dirt roads have been made fifty per cent. more efficient at a less cost for maintenance. The road drag law of that state allows the commissioners to drag the roads by contract, and gives the following rules for dragging:

Make a light drag.
Drive at a walk.
Don't drag a dry road.
Ride on the drag.
Drag when the road is muddy.
Drag, if possible, immediately before a frost.
Begin at one side of the road, returning on the opposite side.

Always drag a little dirt toward the center of the road until it is raised ten or twelve inches above the center of the roadway.

Do not attempt to move very much material at one time with the drag.

If the drag cuts too much, shorten the hitch.

The amount of earth the drag will carry can be regulated by the driver, accordingly as he stands near the cutting end or away from it.

When the roads are first dragged after a muddy spell, vehicles should drive, if possible, to one side until the road has had a chance to freeze or to partially dry out. The exercise of a very little care on the part of the users of the road will do quite as much as the drag towards securing a smoother road. The law provides a penalty for any one who wilfully ruts or cuts up a dragged road.

Some ninety per cent. of the highways of the United States are dirt roads, impassable part of the year because of mud, and

inch-deep with dust at other times. The problem of keeping these roads up to their maximum efficiency at a minimum cost is an important one, and the consensus of opinion among road experts is that the solution of this problem lies in an enforced road-drag law.

The impact, friction and penetration of horses' feet become less destructive with harder, tougher, better bonded road metal. The crushing due to heavy loads can be stopped by increasing the supporting strength of the road, or, better, by making the tire width proportional to the load per wheel. On our cheaper roads the tire should vary from 4 in. wide for 500 lb. per wheel to 6 in. for two tons per wheel. This width could be lessened where springs are used. Also the gage of the front wheels should be decreased until the wheels do not track. Road taxes could well be reduced one half to those using wide tires. Wheels of large diameter are less destructive than those of small diameter. Abrasion by wheels on stone roads could be lessened by cushioning the roads with screenings, or sand, but this cushion would have to be held in place through an efficient bond.

The latest, most acute and most interesting maintenance problem has resulted from the destructive effect of automobile traffic. Roads costing $10 000 per mile have sometimes been almost destroyed in an hour by racing machines. The dust nuisance alone through automobile roads has frequently made living conditions almost unbearable. The auto is the largest factor in destroying our roads as well as in compelling better roads and, therefore, should be specially taxed for maintaining our roads. A speeding auto subjects a particle of road surface to rapidly succeeding forces in opposite direction. These forces are the downward force of load and impact, the horizontal forces of forward and backward shear and the upward force caused by a partial vacuum. Frequently other forces are introduced by the tendency to skid, and by sliding friction in ruts. All these forces succeed each other in a fraction of a second and only the best bonded roads can withstand the effect. On account of the automobile the water-bound macadam is a road of the past. Especially is this true in our arid states where too little water falls on the macadam during the dry months to renew broken bond until it is too late. It is folly to spend a large amount on a water-bound macadam road subject to unrestricted automobile traffic in a region as dry as is Montana.

The various methods tried in an attempt to lessen the dust and to save the roads from destruction by automobiles are

exceedingly interesting. The expense of laying down dust by applying water is prohibitive and might easily run up to five hundred dollars a mile per season. In a moist climate a weak solution of calcium chloride or the granulated compound applied at six- or eight-week intervals has materially reduced the raveling of macadam, the salt taking up moisture from the air, but in a dry climate it would have to be supplemented by sprinkling with water. The salt solution is non-corrosive, clean, odorless and easy to apply, but the effect is temporary, and no permanent betterment to the road results. Emulsions and crude forms of vegetable oil, creosote oil, coal-tar and petroleum having an asphalt base have been used with varying degrees of success. They are sprinkled on the surface and used as bond. Dust picked from roads treated with emulsions and crude oils is apt to be irritating and disagreeable, and at best the results are temporary, the crude oils being more lasting than the emulsions. All roads so treated must receive close attention by the maintenance organization. Ruts and holes must be promptly cut out and the holes refilled and hand tamped. Oiled roads carefully built and carefully maintained are a great improvement over roads not so treated. Heavy asphalt oils give the best results. Coal-tar, a by-product of gas and coke manufacture, refined to remove injurious matter, is becoming widely used to bind roads and prevent dust. In this country most coke is manufactured in beehive ovens and the volatile by-products wasted. It is estimated that we waste over twelve million dollars' worth of coal-tar per year in the United States in manufacturing coke. There is an abundance of soft coal in Montana, and there will soon be a large demand for refined coal-tar for road purposes. One of our beehive ovens went into receivers' hands recently. It is questionable if this would have happened if the management could have saved and made a market for the possible by-products. The consensus of opinion among road experts who have experimented with the various treatments of surfaces seems to be that old macadam roads are best preserved by applications of coal-tar or bitumen. The macadam should be cleaned and dry, the weather warm, and the tar must be of the best quality and applied quickly by forcing it while hot in a fine spray into the voids of the macadam. Too much tar will leave the road slimy or sticky. Coal-tars, however, are not uniform, and some have failed while others have been very satisfactory, therefore care should be exercised in selecting, or failure may result. The Barret Manufacturing Company, of New York, has prepared a

refined coal-tar and guaranteed its quality. This is largely and successfully used in building new stone roads. Tar or bitumen is used as a filler or binder and the resulting road is probably the best modern road for heavy or fast traffic. These roads are variously called tar-macadam, asphalt-macadam, bitulithic, tarmac, warrenite, etc. The tar or asphalt is applied in the filler and not as a surface coat only, and when the roads are well made they require little tractive effort, and are practically dustless and noiseless. They shed water and therefore are not affected by frost, and they stand up well under all kinds of traffic including that of speeding automobiles. The cost varies greatly with the location and the method of construction. Usually it need not be more than a third greater than that of macadam.

Good roads can be maintained only at a considerable cost, yet that cost when compared with first cost is an economic saving. Improved roads should be maintained by the " patrol system " under efficient supervision. Then, and not till then, will the reputation of the highway engineer be safe; and then, and not till then, shall we have good roads.

[NOTE. — Discussion of this paper is invited, to be received by Fred. Brooks, Secretary, 31 Milk Street, Boston, by July 15, 1912, for publication in a subsequent number of the JOURNAL.]

THE HEBGEN DAM.

By Harry H. Cochrane, Member of the Montana Society of Engineers.

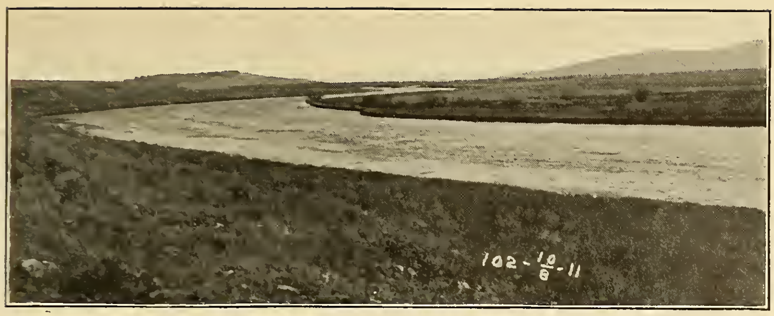
[Read before the Society at its Twenty-Fifth Annual Meeting, held at Anaconda, Mont., April 13, 1912.]

In the Upper Madison Canyon, near Yellowstone Park, the Montana Reservoir and Irrigation Company is constructing a dam which, when completed, will produce one of the largest artificial storage reservoirs in the country. It is called the Hebgen Dam after Mr. Max Hebgen, who originally conceived the idea of making a huge storage reservoir at this point.

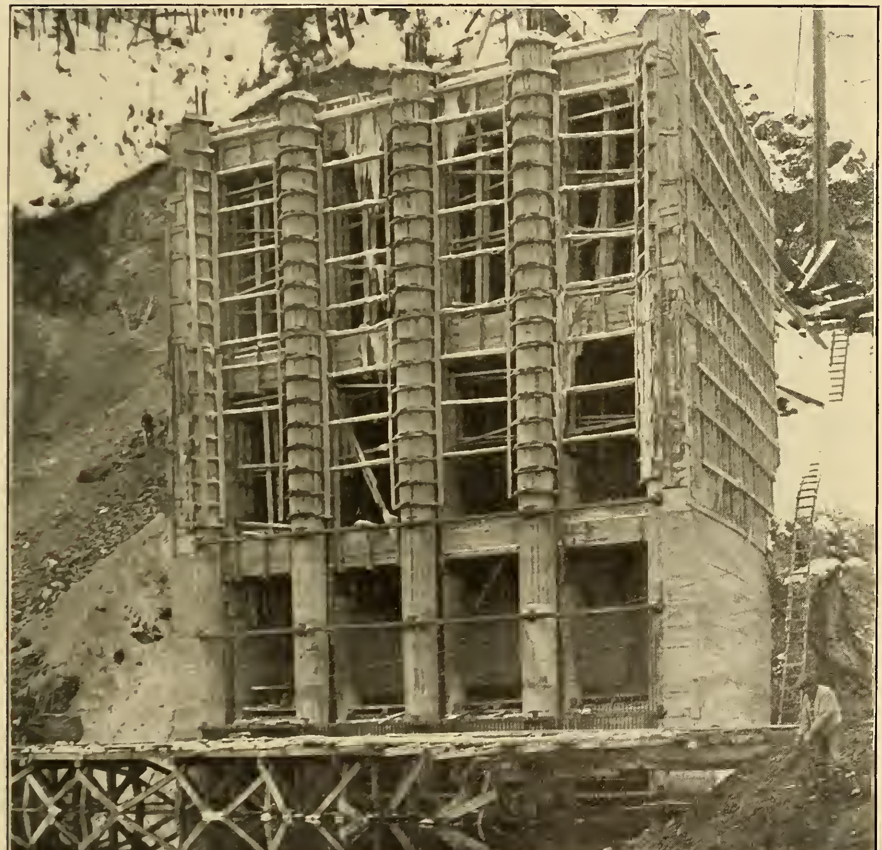
For several years it has been noticed that, due to the use of water for irrigation in various parts of the state, the flow of several of the larger rivers has been materially reduced in July, August and September. This falling off in the flow has been especially noticeable in the Gallatin River and in the Big Hole River. The former is reduced almost to nothing in August, and the Big Hole has only about one half the flow it had before the water was used for irrigation. Irrigation in Montana, however, is only in its infancy, and a survey of the land which can be irrigated in the valley of the Missouri and its tributaries shows four localities where land to the extent of 77 000 acres stands ready for the application of water. This total is made up of 30 000 acres in the Upper Madison Valley, 20 000 acres in the Prickly Pear Valley near Helena, 20 000 acres near Ulm and Riverdale about twenty miles southwest of Great Falls, 1 000 acres at Cascade and 6 000 acres at Sand Coulee, ten miles south of Great Falls.

All of this land, with the exception of that in the Upper Madison Valley, must be irrigated by pumping. The Madison Valley land can be irrigated by a gravity ditch. The total amount of water required for this irrigation will be approximately 770 second-feet, and the amount of power required for pumping approximately 8 000 h.p.

To produce this power in the present power plants on the Madison and Missouri rivers will require some additional 400 second-feet, but inasmuch as this water can be used twice to a certain extent (i. e., water which would be used near Great Falls for irrigation can first be used in the power plants on the Madison River and at Canyon Ferry and Hauser Lake), it follows that only



River above Dam — looking up stream.



Gate Tower.

180 additional second-feet will be required for furnishing power to the extent of 8 000 h.p. for pumping. This makes a total of 950 or practically 1 000 second-feet which will be used either directly or indirectly for irrigation in the near future. It was to supply this water and foster these irrigation projects that the Montana Reservoir and Irrigation Company was formed.

The projects at Prickly Pear, Cascade and Sand Coulee are being actively pushed, and the land at these points will be under water next year. The pumping station at Cascade will be installed this spring, and part of the land at least will be under irrigation this year. The Madison Valley project will probably follow after the completion of the dam.

To supply the 1 000 second-feet which are required, without interfering with the present flow of the rivers, requires an amount of storage which could be provided at a reasonable cost only under very favorable conditions. These favorable conditions were a comparatively narrow canyon for a dam site immediately below a large flat basin for a reservoir site.

The minimum flow of the Madison River at the dam site is 600 second-feet; the maximum flow, occurring in May and June, is about 4 000.

The reservoir will have a capacity of 344 000 acre-feet, or 15 billion cu. ft. It has an area of 13 400 acres, or 21 sq. miles, and a contour line 65 miles long. When the reservoir is filled it could supply 3 000 second-feet, or a flow equal to the usual flow of the Missouri at Great Falls continuously for a period of two months, or 1 000 second-feet for a period of six months.

To hold this immense amount of water it was imperative that a dam be built with as great a factor of safety as was within reason, for a break in a reservoir dam of this size would mean a flood which would probably endanger many lives.

The canyon in which the dam is located has a steep, rocky cliff on the west side and a sloping bank of gravel and clay on the east side. Lack of a good abutment on the east side made a masonry dam unfeasible. The fact that the dam would be alternately wet and dry in different seasons of the year would make a crib dam impracticable on account of its short life; also a reservoir dam of this character required no overflow. Therefore it was decided to make the dam an earth fill.

The dam will raise the water 80 ft. above its present level. The dam itself, however, will be 120 ft. high from the foundation of the core wall to its crest. The crest line will be 700 ft. long. The width of the dam at the top will be 20 ft. with a 3-to-1 slope

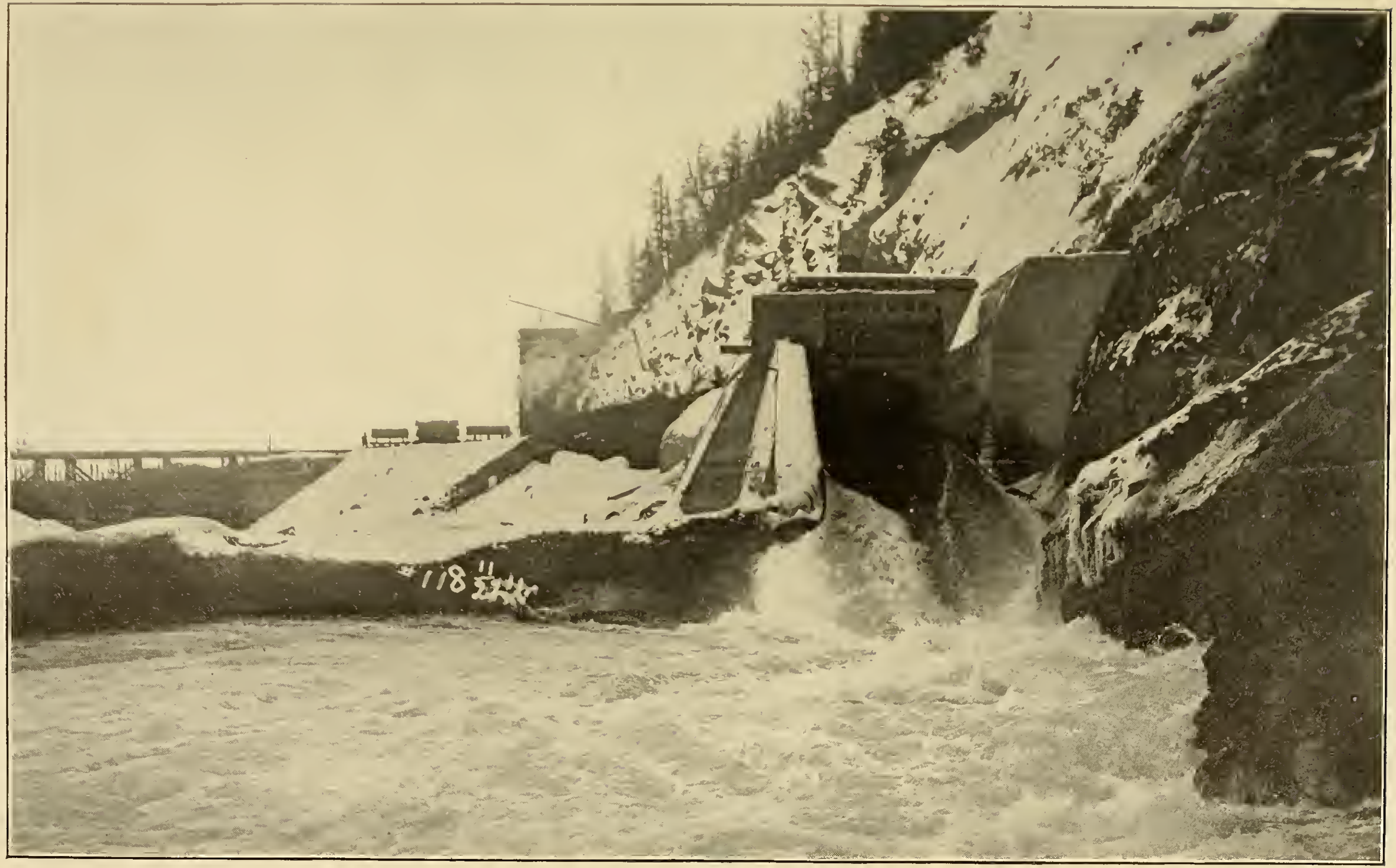
on the upstream side and a $2\frac{1}{2}$-to-1 slope on the downstream side. The concrete core wall will be 16 ft. thick at the bottom and 3 ft. at the top. It is founded on bed rock throughout its entire length and extends the length of the dam.

An important point in the design of the dam is that the upstream fill will be made of a solid impervious mixture of clay, sand and gravel. This material is found in large quantities on the east bank of the reservoir. The downstream fill, however, will be made largely of large rock, coarse gravel and other pervious material, the idea being that if for any reason the core wall should develop a leak, on account of settlement or possibly an earthquake shock or other unforeseen cause, then the impervious upstream fill would prevent any great amount of water leaking through, but any water which did leak through would run freely through the downstream fill without washing it away. The downstream fill is depended upon for stability and the upstream fill for watertightness.

To regulate the flow of the river there has been provided a 12-ft. outlet pipe running under the dam and connected with a concrete gate tower by means of which water can be let out of the reservoir at any rate up to 1 500 or 2 000 cu. ft. per second from any water elevation. The outlet pipe is of concrete with walls 3 ft. thick and lined with wood. At its intersection with the core wall the walls are thickened to 6 ft. to guard against a crack at this point due to unequal settlement.

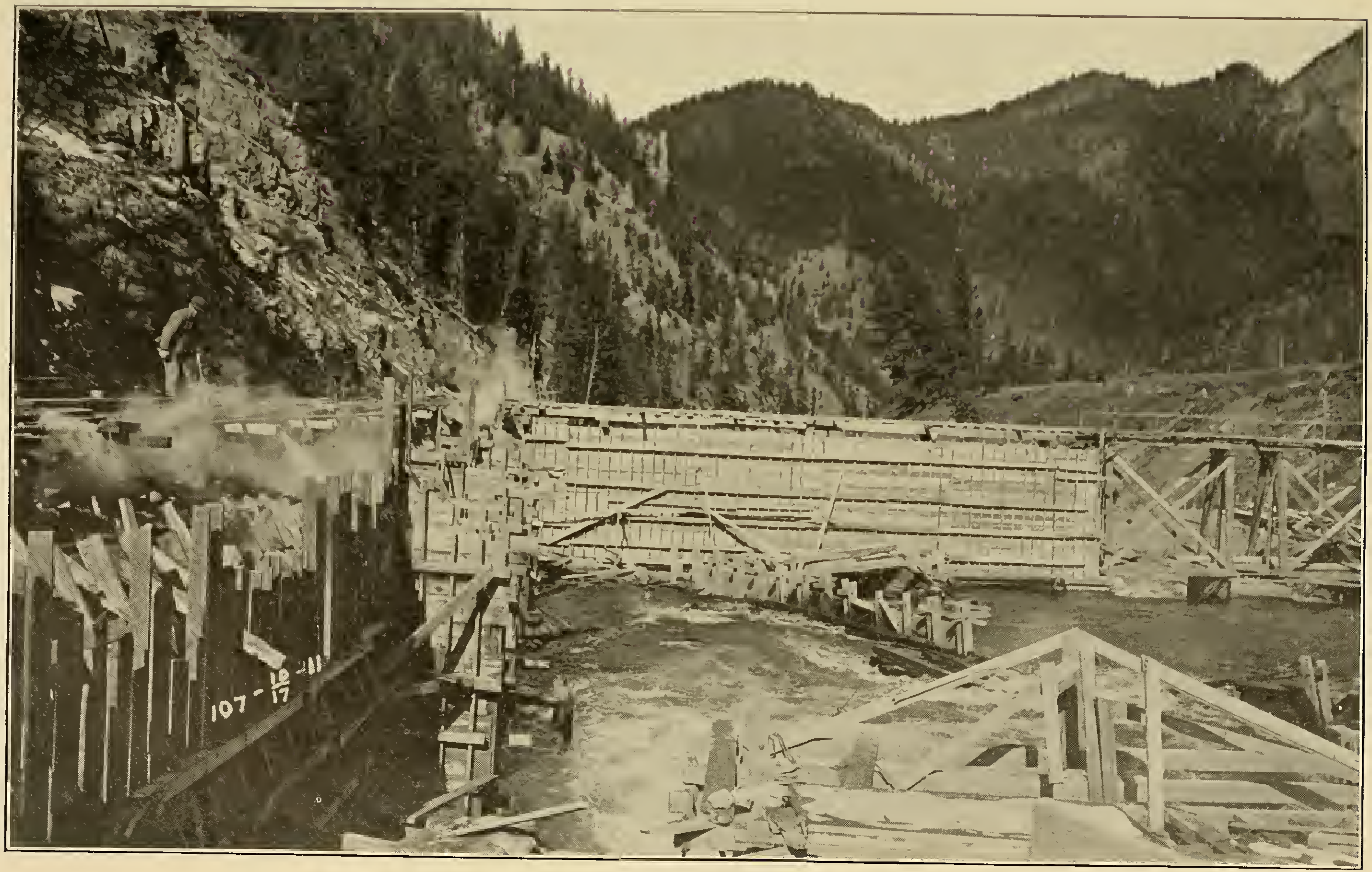
The gate tower is a rectangular structure 25 by 51 ft. in plan and 75 ft. high. On one side there are four vertical openings each 8 ft. wide, extended from top to bottom, closed by removable wooden stop logs. It is by means of these stop logs that the flow from the reservoir is controlled. The stop logs are notched at the ends and a chain hoist is arranged to raise and lower the stop logs by means of hooks fitting into the notches in the ends of the logs. The bottom of the tower is sheathed with iron rails to guard against abrasion by the water falling over the stop logs from the top. The design of the outlet works is such, however, that when there is any considerable amount of water flowing into the tower there will be some 20 or 30 ft. of water at the bottom to act as a water cushion and to prevent any undue wear.

In addition to this outlet there will be provided an emergency spillway on the east bank having a capacity of 3 000 second-feet. This spillway will also be controlled by stop logs, and carry the water through a cement-lined ditch to a point about 1 000 ft. below the dam, where it will be discharged into the river.

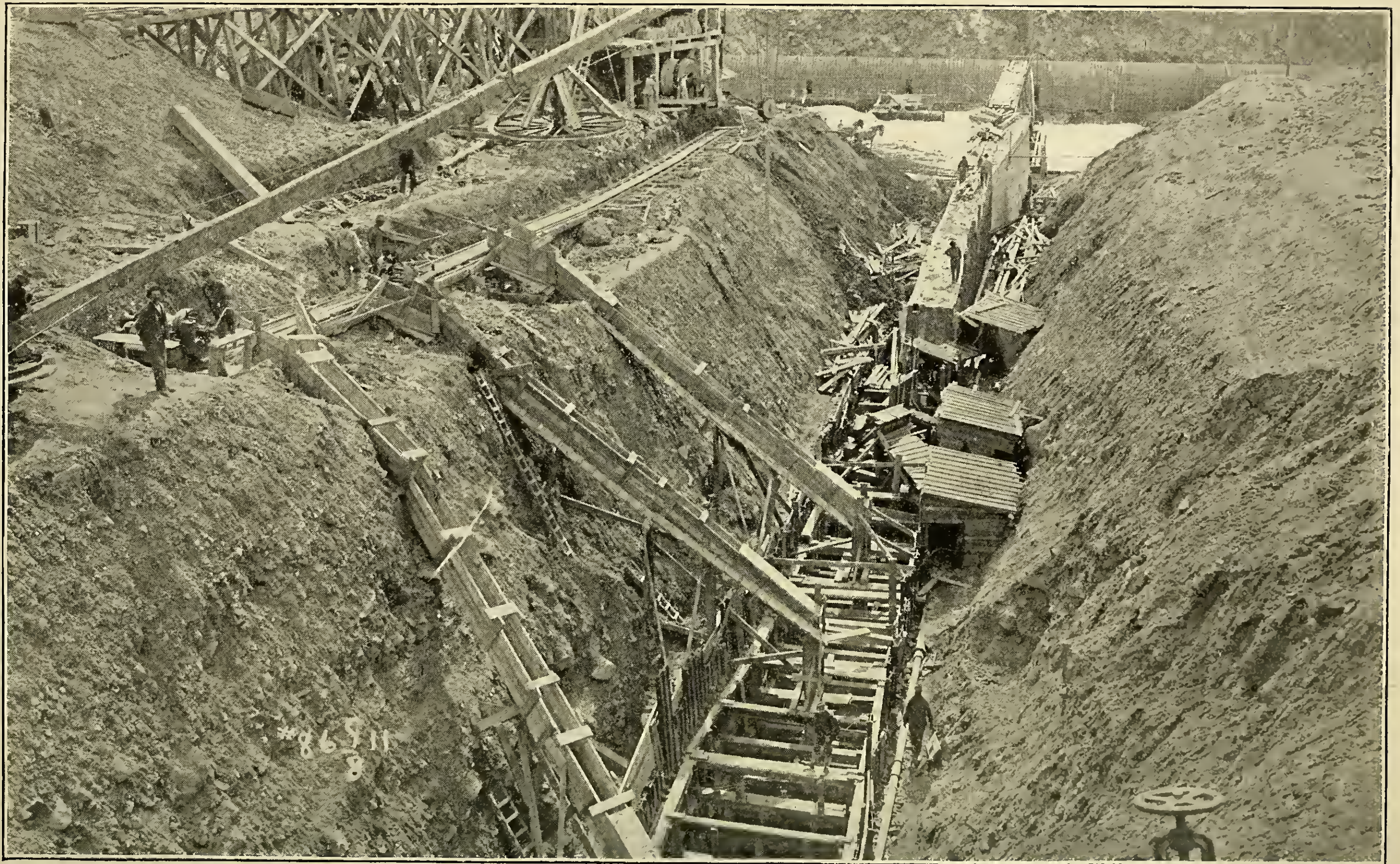


Pipe Outlet.

General View of Construction.



West End of Core Wall — looking down river.



Concrete Core Wall.

Before construction was commenced test holes were drilled at intervals of 50 ft. entirely across the proposed dam site. Bed rock was encountered about 20 ft. below the river bed, and this rock extended at practically the same level entirely across the river under the east bank. To determine with a greater degree of accuracy the character of the east bank, two test pits were sunk until bed rock was encountered.

A satisfactory foundation having been secured, work was started on the trench for the core wall. This trench was extended into the east bank the entire length of the dam. The upper part of the trench was an open cut, and the lower part was made by driving two rows of steel sheet piling to bed rock and excavating between the piling, the space between the piling afterward being filled with concrete to form the core wall. The outlet pipe was made by first building a 12-ft. wood stave pipe as an inner form and lining. This was then covered with concrete, the steel bands of the pipe forming a reinforcement for the concrete. The gate tower, being subject to a considerable pressure when empty, was heavily reinforced with twisted bars.

At the present time the most difficult part of the work has been completed. The core wall is completed throughout its entire length to an elevation 30 ft. above the water. The downstream and upstream fills are also raised to this same elevation. The outlet pipe and gate tower are completed, and another year's work will probably see the completion of the entire structure.

[NOTE. — Discussion of this paper is invited, to be received by Fred. Brooks, Secretary, 31 Milk Street, Boston, by July 15, 1912, for publication in a subsequent number of the JOURNAL.]

DISCUSSION OF PAPER, "DEVELOPMENTS IN THE ILLINOIS OIL FIELDS."

(Volume XLVIII, Page 68, February, 1912.)

Mr. H. L. Hutson. — There has been a recent increase in the production of oil in Louisiana, — the amounts for the year 1911 and for the ten years 1902–1911 inclusive being given below by districts.

District.	Year 1911.	Ten Years 1902–1911.
Jennings	$1 123 124	$40 573 631
Welsh	40 150	287 711
Anse la Butte	29 200	397 378
Caddo	8 359 662	15 551 855
Vinton	3 232 673	3 303 582
	$12 784 809	$60 114 157

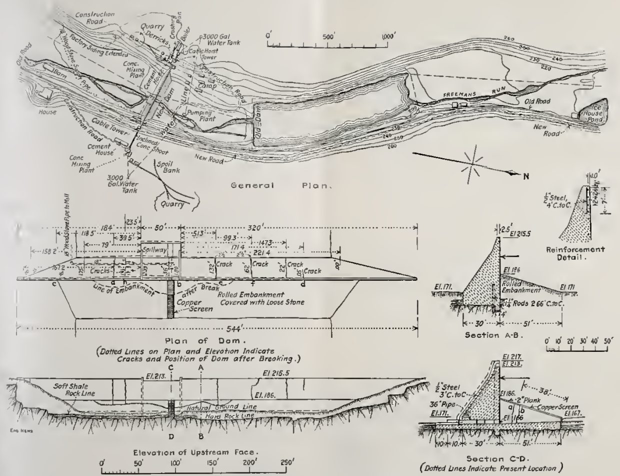


FIG. 1.

GENERAL PLAN AND DETAILS OF CONCRETE DAM, AUSTIN, PA.

Reproduced from *Engineering News* of March 17, 1910.

Editors reprinting articles from this JOURNAL are requested to credit the author, the JOURNAL OF THE ASSOCIATION, and the Society before which such articles were read.

ASSOCIATION
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VOL. XLVIII. JUNE, 1912. No. 6.

THE AUSTIN DAM FAILURE.

[A Discussion before the Boston Society of Civil Engineers, December 12, 1911.]

THE CONCRETE DAM AT AUSTIN, PENNSYLVANIA.

BY FRANK P. MCKIBBEN.*

Location and History.

AUSTIN, PA., before being destroyed by the flood on September 30, 1911, had a population of approximately 2 500. A small stream called Freeman's Run passed through the village, and on this stream above Austin was a concrete dam owned and built by the Bayless Pulp and Paper Company of Binghamton, N. Y. The village of Costello is located further down the valley a few miles below Austin.

The Bayless Pulp and Paper Company used considerable water for manufacturing purposes in their mill, which is located about one and one-half miles above Austin; and about ten years ago this company impounded a reservoir in Freeman's Run, but as the demands on this reservoir increased, the company decided to store larger quantities of water to serve during low stages. Mr. T. Chalkley Hatton was engaged to design and

* Professor of Civil Engineering at Lehigh University.

To the Engineers' Society of Pennsylvania grateful acknowledgment is made, especially for supplying the plates accompanying the paper which Professor McKibben presented to that Society in a form a little different from this, which is the basis of the discussion.

supervise the construction of a concrete dam, which was placed below the old dam and above the Bayless Company's plant and hence above the town of Austin. This dam was begun in May, 1909, and completed about December 1, 1909, the contract for construction being let to C. J. Britnall & Co., of Binghamton, N. Y.

Freeman's Run is only about 350 ft. wide at the site of the dam and has steep slopes rising several hundred feet on either side. The valley is quite straight from the dam to Austin, so that when the concrete dam failed on September 30, 1911, the flood destroyed most of the town of Austin, which was located in the valley.

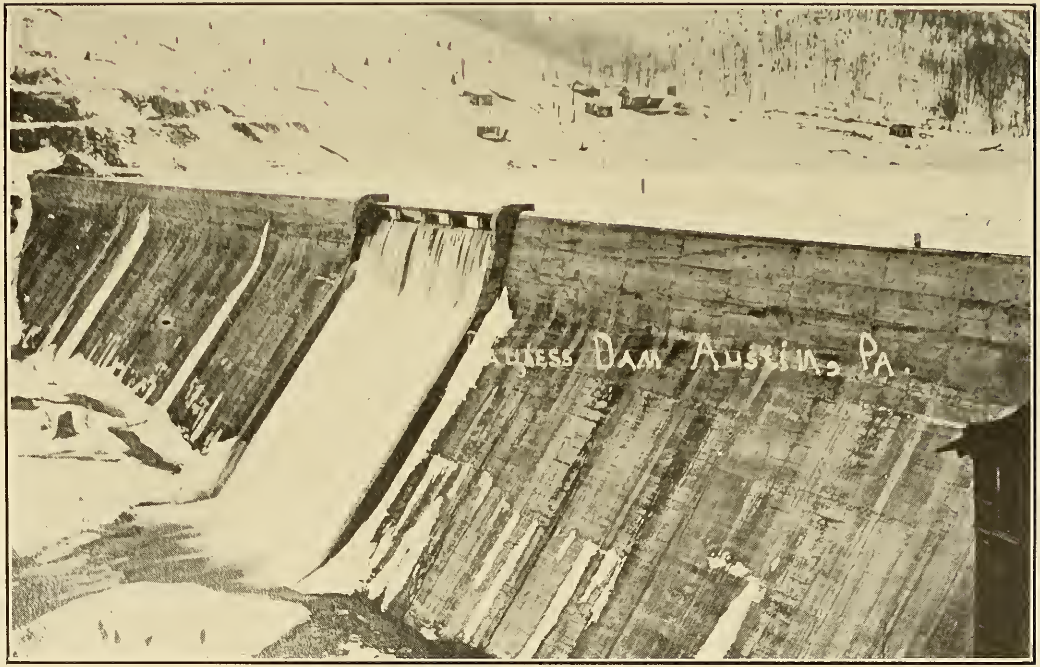
Details of Construction.

The following description of the construction and the accompanying Fig. 1 are taken from *Engineering News*, March 17, 1910.

"The entire valley is underlaid with sandstone rock in horizontal layers running from 8 in. to 3 ft. thick. Between these layers beds of shale and disintegrated sandstone were located, but there were very few vertical cracks to be observed in the bed of rock. Upon the surface of the rock there was from 5 to 8 ft. of earth and compacted gravel deposited from the washings of the side hills. This was so well cemented together that it was removed with the utmost difficulty, and but little water filtered through it into the foundation trench during construction.

"In preparing the foundation all loose rock was removed and the concrete only started after a solid stratum of at least 2 ft. thick was encountered. The surface of the rock was well washed and grouted. A cut-off wall 4 ft. thick and 4 ft. deep was built, as shown upon plan, Fig. 1, and in every case this cut-off wall was carried down to good rock. In order to reinforce the dam, twisted steel rods $1\frac{1}{4}$ in. in diameter and 25 ft. long were built into the wall vertically 5 ft. inside of the upstream face. Holes were drilled into the foundation rock from 5 to 8 ft. deep, and 2.66 ft. between centers, and the steel rods with expansion-bolt heads were placed into these holes, which were then grouted.

"Upon each side of the spillway a pilaster was built which was reinforced by $\frac{1}{2}$-in. steel rods to prevent cracking. The top 12 ft. of the dam was reinforced with $\frac{1}{2}$-in. steel rods spaced 2 ft. vertically and 4 ft. horizontally to prevent cracking. Against the upstream face of the dam an earth embankment was laid at a slope of 3:1 and reached to within 27 ft. of the normal water level at the upstream face of the dam. This embankment was composed of disintegrated shale, clay and some loam, free



Bayless Dam before Failure.

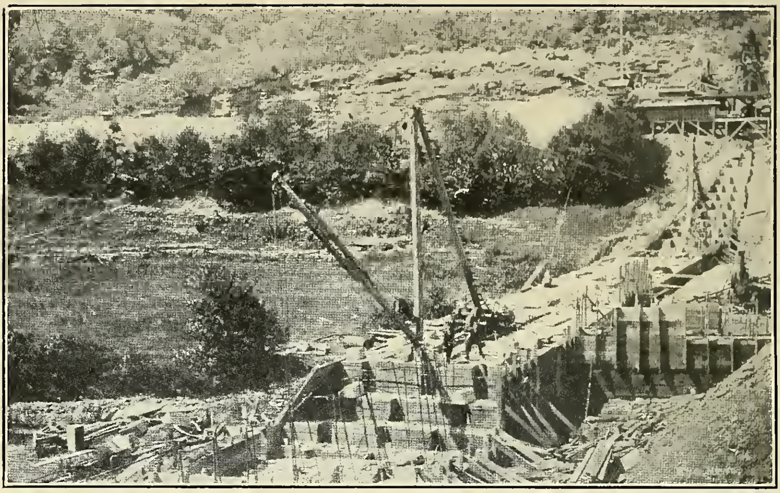
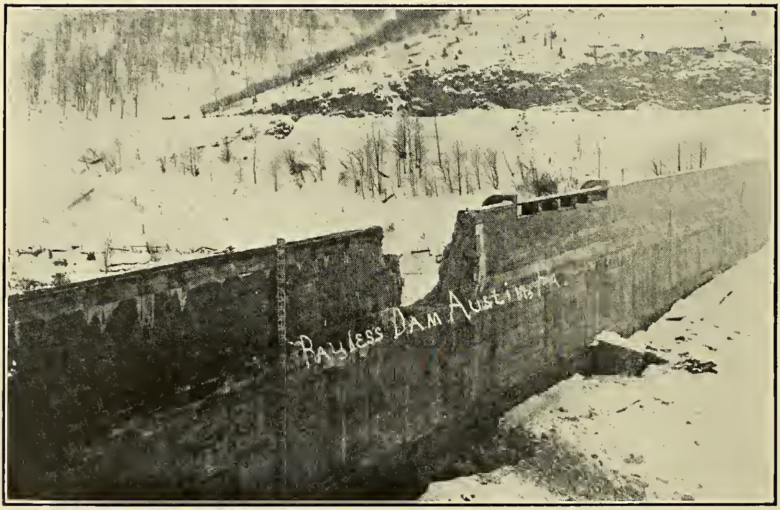


Fig. 2. View of Austin Dam during Construction.



Bayless Dam after Dynamiting in 1910.

from large stones, and was carefully compacted by grooved rollers in 6 to 8 in. layers, the work being carefully and well done.

"The dam was composed of cyclopean concrete, with large quarry stones from $\frac{1}{2}$ to 2 cu. yd. size, embedded firmly in wet concrete. These stones were placed so as to break joints, both as headers and stretchers, and surrounded with not less than 6 in. of concrete, generally much more. In every case the concrete was built in sections, stepped up as shown in Fig. 2, and the steps dovetailed both horizontally and vertically. In building into the side hills great care was used in getting down to good firm rock foundation before any concrete was laid.

"The material for building the dam was secured from quarries opened at either end of the dam, where duplicate crushers and mixing plants were located. The sand was secured by crushing the sandstone with rolls and screening through sand pans. The composition of the concrete was one part Portland cement, three parts of sand and six parts of broken stone. Each shipment of cement, as received, was tested upon the works by the resident engineer, who also made numerous tests to ascertain the difference between the tensile strength when using washed bar sand and the sand secured from crushing the stone. In every case the mixture containing the sand from the crushed stone gave the greater tensile strength.

"The concrete was handled in two ways. At the two ends it was run down chutes upon the dam, and there shoveled into place. In the middle of the valley the cableway stretched across the valley carried the concrete in buckets to the wall, where it was shoveled into place. In every case it was well turned over and mixed after leaving the mechanical mixer."

Referring to Fig. 1, it is seen that the dam was 544 ft. long and that the maximum section was practically 50 ft. in height, 30 ft. thick at the base, diminishing to 30 in. at the crest, with upstream face vertical and downstream face inclined.

The Preliminary Failure of January, 1910.

After completion in December, 1909, and before there was any water in the reservoir, two vertical cracks appeared in the dam, — one 51.3 ft. to the west of the spillway and the other 39.5 ft. to the east thereof. These cracks were about 1-16 in. wide and extended from the ground to the crest and were due to contraction. On January 21, 1910, the reservoir was full and water was flowing over the spillway. On January 22, there was a landslide of the east hill on the downstream side of the dam, and water was issuing from this slide. Furthermore, water passed under the structure and came up through the ground on the downstream side several feet below the dam. The next day that portion of the structure between *a* and *b* slid down-

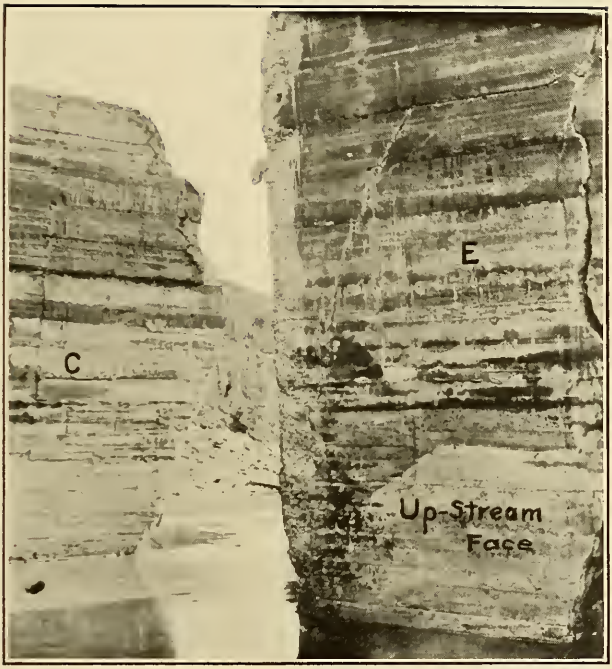
stream 18 in. at the bottom and 31 in. at the top, and, according to *Engineering News*, this sliding was "a maximum at a joint *h* and running out to nothing at *c* and *d*." The crack at *a* opened 4 in.; at *h*, $4\frac{1}{2}$ in., and at *e* and *f*, $2\frac{1}{2}$ in. at the bottom on the downstream face, but pinched nearly together on the upstream face." The reservoir was then emptied and the water pressure on the upstream face was thus released by removing, with dynamite, an upper portion of the dam at the west end, a large V-shaped section nearly 15 ft. deep just east of the spillway, and also a wooden cap from the downstream end of the clean-out pipe. After the reservoir was emptied it was seen that the rolled embankment which had been originally placed against the upstream face, as shown in Fig. 1, had been washed out for a distance of about 100 ft. on each side of the intake chamber and that each side wall of this chamber had a crack about 18 in. wide. These side walls of the chamber were perpendicular to the dam's upstream face so that a motion of 18 in. at the bottom of the dam caused a corresponding crack of 18 in. in the walls, and a portion of each wall remained attached to and moved with the dam when it slid.

Cause of Failure in 1910.

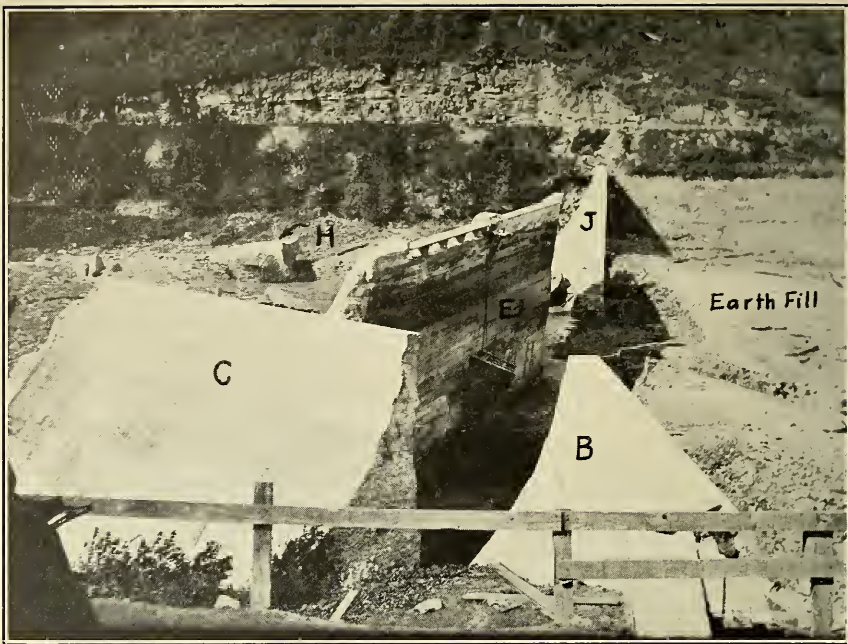
The cracking and movement of the dam above described was attributed to the sliding of the dam "due to the water getting under the foundation, softening up a stratum of clay or shale lying between two layers of rock and permitting one layer of rock to slip forward about 18 in. upon the lower layer." After the structure had thus failed, nothing was done to strengthen it, but water was again allowed to collect behind it so that in March, 1910, there was a depth of 36 ft. of water in the reservoir, and later in the same month the water rose to within 2 ft. of the overflow and two streams were passing under the dam, appearing about 10 ft. below the toe, and another stream was passing around the east end of the dam. It is evident that the clean-out pipe was closed so that the reservoir had considerable water in it within two months after the first failure.

Proposed Strengthening after the Failure of 1910.

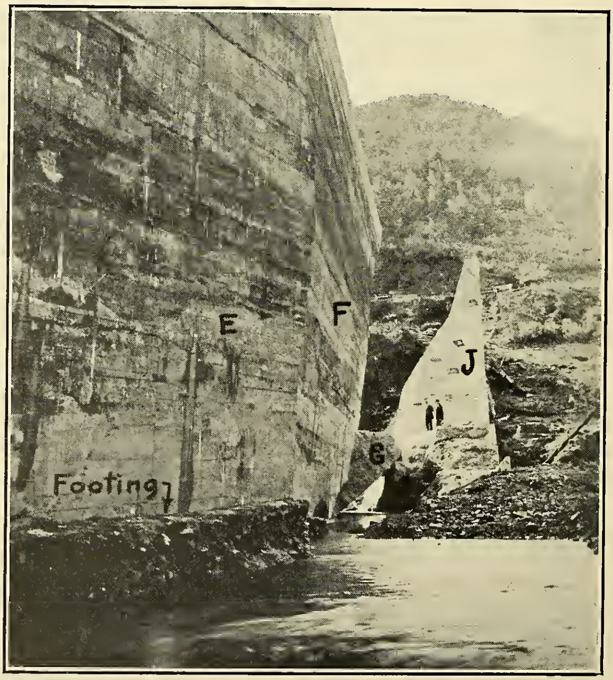
After the dam slipped and cracked in February, 1910, the owners had Mr. Hatton submit a plan for strengthening the structure, but nothing was done to carry out the recommendations made. When the dam failed on September 30, 1911, seventy-seven people lost their lives and the two villages of



Looking Downstream.



DAM AFTER FAILURE IN 1911. LOOKING WEST.



FOOTING OF E VISIBLE. VIEW TOWARDS WEST.

Austin and Costello were practically destroyed. Between the preliminary failure of 1910 and the disaster of 1911 practically nothing had been done to strengthen the structure.

The Demolition of the Dam on September 30, 1911.

On the morning of September 30, 1911, water was issuing from the cracks in the dam, and in the early afternoon water was flowing over the spillway. At 2.20 P.M. the portion of the structure at the bottom near the west end burst forward and was immediately followed by a complete demolition of the structure.

Conditions of the Structure after Demolition of 1911.

The speaker examined the wrecked structure on October 2 and 3, 1911, and again quite carefully on October 31 and November 1, 1911, and as a study of the fragments yields valuable information and throws much light on the cause of the failure, a detailed description of the broken dam will be here given. Of the original length of the dam, about one fourth, or 129 ft., remains practically intact, the balance of 415 ft. having been broken up and moved downstream. Referring to Fig. 4 it will be seen that a short piece, *A*, at the east end remained practically intact as did also piece *J* at the west end. Between these two end pieces there are seven large fragments, and although there are many smaller pieces of the dam lying as far as several hundred feet downstream from *F* and *G*, it is with the nine major pieces *A* to *J*, inclusive, that most interest centers. As one examines the structure he is impressed with the fact that four of the largest sections moved, namely, *B*, *C*, *E*, *F*, simply slid downstream, remaining nearly vertical, and are now standing from 5 to 50 ft. below, and rotated from the original alignment of the structure. The other three sections were moved downstream and overturned. The earth fill has been washed out immediately behind the dam, but a considerable area of this fill, together with its slope-paving, remains in place, thus leaving a rather steep bank on the side of the fill towards the upstream face of the dam. As water rushed through the openings between the broken sections, it washed out a large basin at the west end, below and around fragment *G*, and a smaller one opposite the opening between *E* and *F*. The stream now passes through the earth-fill at the sluice-way walls, which remain nearly intact, thence around the east end of large fragment *E* through the easterly gap between *E* and

B. Water stands in the basins below and around the fragments, so that only the upper part of the footing course is visible on a few of the pieces.

Except for a few small cracks, section *A* is intact in its original position and is 19 ft. long on the crest. At its westerly end its maximum thickness is about 4 ft. The east bank almost entirely covered this fragment, but erosion has exposed it to view.

Section *B*, 39 ft. long on the crest, remains upright but has rotated through an angle of about 10 degrees, and because of rotation and its sloping east face, the east end of the crest has moved upstream 3 ft., while its west end has moved downstream 6 ft. The upper part of the footing course is exposed and shows that the dam and footing are not separated but have moved together, the plane on which sliding occurred being below water level either at the junction of the concrete footing with the rock stratum or else between two strata underlying the concrete. At the westerly end this section is 18 ft. 9 in. thick at a depth of 38 ft. below the crest, continuing with this thickness to the base, which is 49 ft. 6 in. below the crest. A greater part of this piece was embedded in the hillside, and though the wisdom of reducing the thickness of the base of a 50-ft. dam from 30 ft. in the valley to 18 ft. 9 in. in the bank may be seriously questioned, nevertheless this reduced thickness has absolutely no bearing on the failure of the Austin dam.

Section *C*, about 75 ft. long on the crest and 90 ft. at the base, broke squarely through the dam from crest to bottom, except that the west upper corner is broken off. This broken corner corresponds in size and position to a portion of the gap that was made east of the spillway in 1910 by blasting, and which was later filled with a V-shaped mass of concrete. Section *C* has moved about 50 ft. downstream, rotated through an angle of 60 degrees and remains standing on its base in practically an upright position, though its top is slightly tilted upstream and the crest is about 5 ft. below its original level. Here is perfect evidence of sliding, but whether rupture took place on a horizontal plane in the concrete footing, or on one between the concrete and rock bottom or on a plane between two rock strata, can be determined only by pumping and excavating. The only rods visible in this fragment are small form rods projecting from the east ruptured surface. A part of the footing course is visible above water.

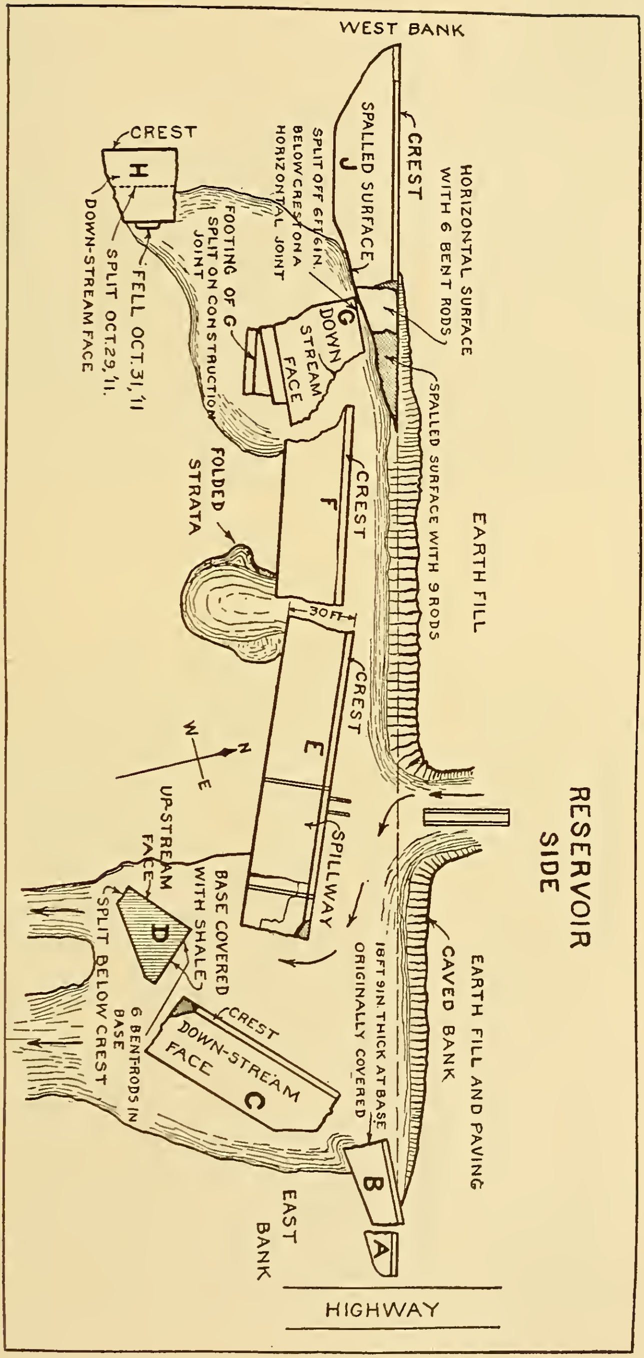
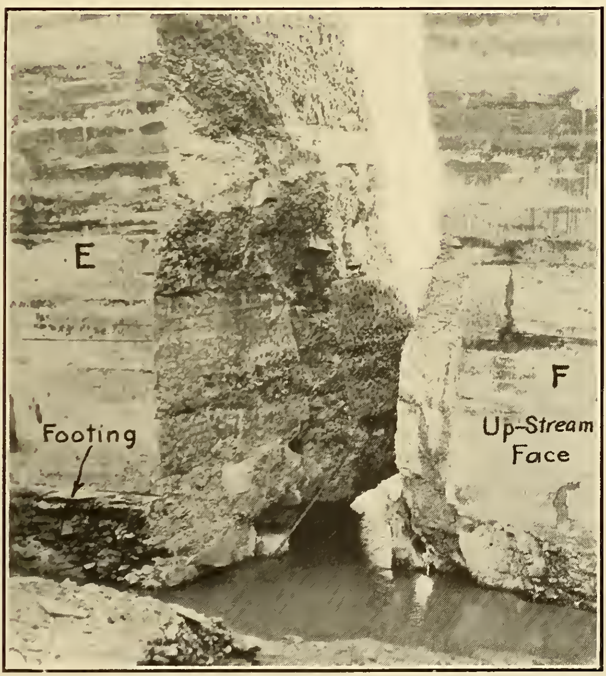


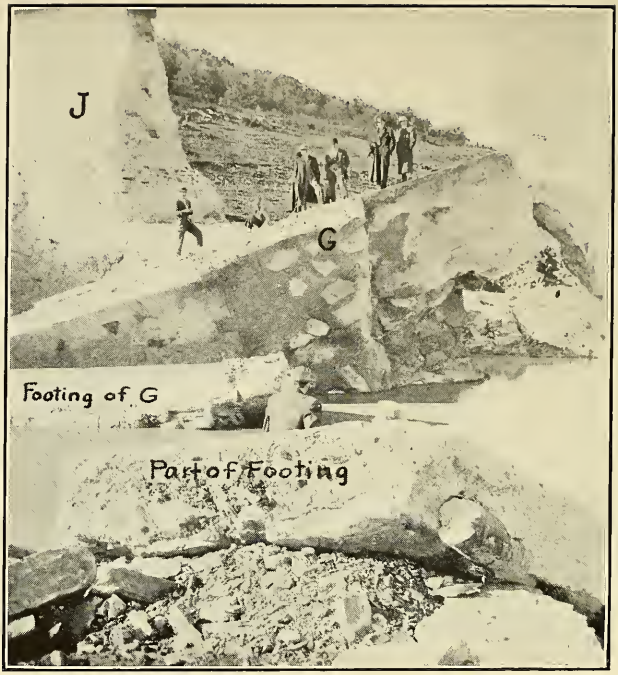
Fig. 4. Sketch Plan of Demolished Austin Dam.

Section *D*, which lies about 100 ft. downstream, is the lower portion of the dam and came from the gap between *C* and *E*, the upper part being washed away. Section *D* corresponds to the short piece east of the spillway between the two old cracks shown on elevation of upstream face in Fig. 1, and is without doubt the part of the original section which was under the portion blasted out east of the spillway, and the depth of the notch made by blasting corresponds very closely to the depth of the part that is missing. The section *D* lies on its west fractured plane with a large part of its base exposed above water and with its original upstream face vertical and making an angle of about 45 degrees with the dam. Its average length is about 16 ft., thus corresponding with the 16-ft. section between old cracks *a* and *h*, Fig. 1. The fact that this fragment came from under the blasted portion, with which it must have had a very poor bond, and from between the two cracks, together with the fact that it is so far removed downstream, and that fragments *B*, *C*, *E* and *F* are all turned towards it, points very strongly to this as one of the first pieces to give way. It should be remembered, too, that this section *D* was at or near the point of maximum movement of 1910. Hence, many things point to first failure having occurred at section *D* by sliding, and if the eyewitnesses to the failure are correct when they testify, as they have done, that the first break occurred near the west end, it must be said that since there are also good reasons why failure should occur at the west end, and that as the time interval between the collapse of the two portions under consideration must have been very small, it is either impossible to tell which gave way first, or else the witnesses could not clearly record the proper sequence of events which must have occurred so quickly. It makes little practical difference which section moved first since both were unsafe and there were ample reasons why both should fail. There is no visible shearing or splitting of any of the sections near the east end as are so evident at the west end. The base of this small section *D* is quite smooth and is covered over about one half its exposed area with a very thin layer of rotten shale varying in thickness from $\frac{1}{4}$ in. to $1\frac{1}{2}$ in. and adhering to the concrete. Here is absolute proof that this section was placed on quite a large area of thinly stratified rock of a rotten texture. This section clearly slid on its base on a horizontal plane at junction of concrete and the thin shale. Parallel scratches in this shale indicate sliding. There are six $1\frac{1}{4}$-in. twisted rods projecting from the bottom of fragment *D*,

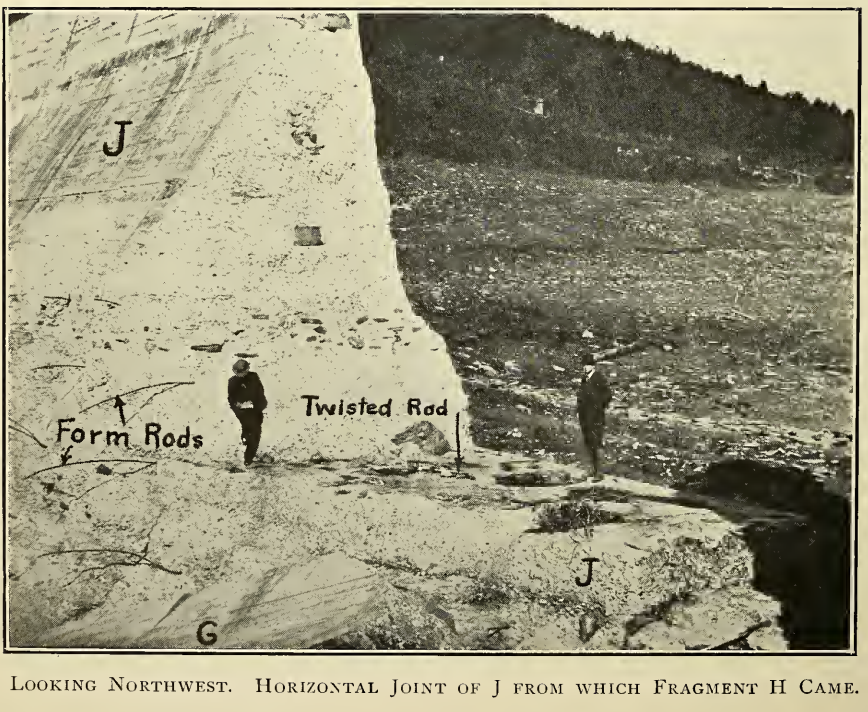
Looking Downstream. Base of D Visible.



Opening between E and F.



LOOKING UPSTREAM. SEPARATION OF FOOTING FROM G.



LOOKING NORTHWEST. HORIZONTAL JOINT OF J FROM WHICH FRAGMENT H CAME.

five of which are broken by tension, the sixth having pulled out of the foundation, and all are bent. There is excellent evidence that no cut-off wall existed on this section.

Section *E* contains the spillway; is about 115 ft. long on the crest and has slid downstream 36 ft. at its east end and 20 ft. at the other. Its thickness at base measures 30 ft. It stands practically upright except that its east end is about 4 ft. below its original elevation, while the west end is within 1 ft. of that level. The upper east corner is broken off as if along the junction with the blasted section east of the spillway. This fragment *E* is the largest of all the pieces, and that it has slid on or in the rock strata, and not at the top of the footing, is clear because a considerable portion of the footing is visible on the upstream side. A large vertical crack in the east end of the spillway section nearly divides this fragment into two pieces. Except for a large smooth vertical area on the west ruptured surface of this section, caused by wooden forms in construction, there is nothing further about this piece that calls for comment.

Section *F* is also a large fragment having a length on top of about 90 ft. and on the bottom of about 70 ft., standing slightly tilted upstream with its east end 25 ft. and its west end 20 ft. downstream. The crest at the west end is several feet below its original level and at the east end it has sunk only a small amount. There is nothing of special note about this section more than to state that it has slid on or in the rock strata and that its west ruptured section instead of being a fairly complete transverse plane is ragged, with the crest overhanging the lower part of the fracture. A part of the footing is visible above water.

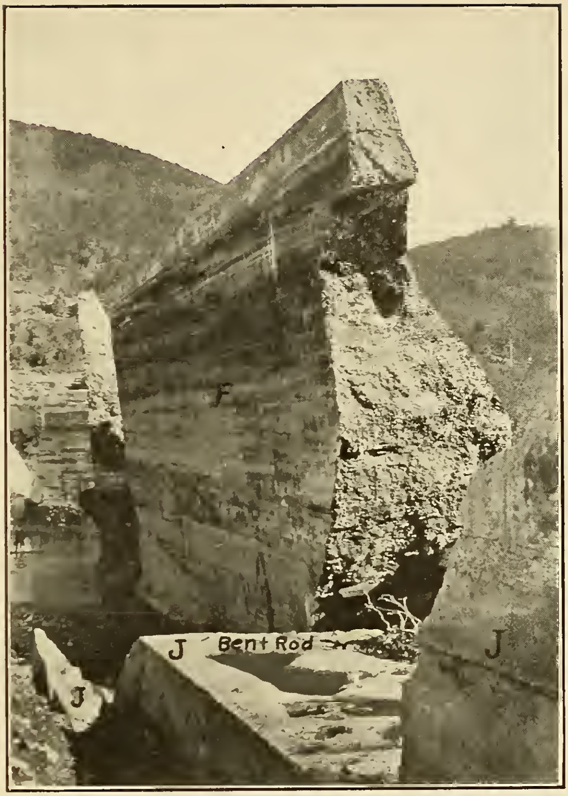
Section *G* varies from 26 ft. long at its upper edge to 47 ft. long at the bottom and lies on its upstream face below the dam with its base downstream. The upper part of this section for a depth of 6 ft. 6 in. below the crest has separated on a large smooth plane and has been washed downstream, a part now lying under fragment *H*. What is of greater importance is that the footing course has parted from the main portion of the dam and lies a few feet from it. The bottom of the main portion and the top of the footing, which were originally horizontal, are very smooth, showing clearly that this large area was a horizontal joint through the dam at junction of main section and footing, the visible part of which averages 15 ft. wide by 31 ft. long. From the position of the footing it is apparent that this section *G* slid out at the bottom on a plane between the concrete and rock, and being somewhat held at the crest, was turned over so

that its crest fell upstream, the footing separating from the main section during this movement. As previously mentioned, eye-witnesses have testified that the first break occurred at the bottom near the western end, and if they are correct this is undoubtedly the piece that first gave way. The dam slid upon the rock at this point. No reinforcing bars whatever show either on the base of the main portion or in the footing as far as these are visible, but nine $1\frac{1}{4}$-in. twisted rods are projecting from the long pointed part of fragment *J*, on which fragment *G* originally stood. Of these nine rods, five show tension breaks with a reduction of area of 50 per cent., while the other four rods are bent downstream but are unbroken.

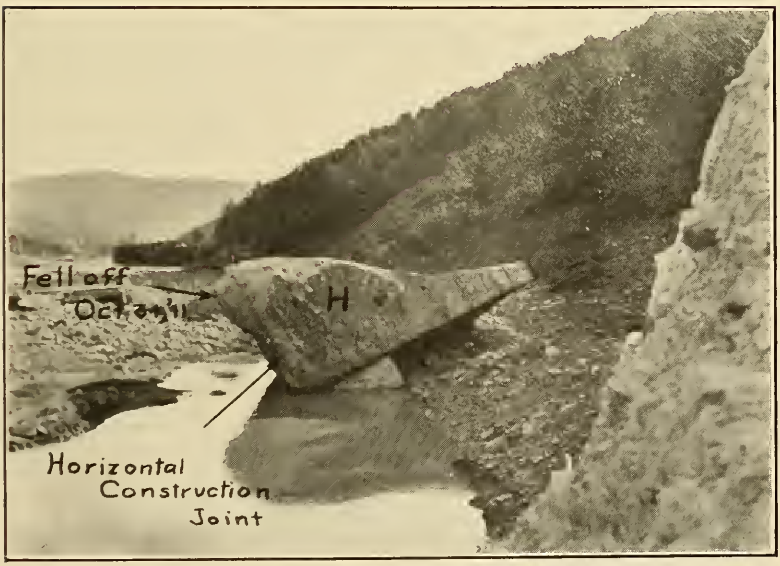
Section *H* has moved 110 ft. downstream and is lying on its upstream face with the crest pointing towards the west. It is 34 ft. long on the crest and is the upper 34 ft. of the main section of the dam. Except for one projection mentioned below, this fragment had a fairly smooth base, thus showing the presence of a horizontal construction joint. In other words, this section slid off at a horizontal joint 34 ft. below the crest and was originally between *G* and *J* and resting on a flat portion of *J*, which is still in place. This is the only place in the entire structure where concrete slid on concrete, and with the exception of section *G* is the only piece in which there is an important separation of concrete on a horizontal plane. On October 29, 1911, this fragment *H* broke in two from cantilever action on a horizontal construction joint 17 ft. below the crest, showing a smooth surface 9 ft. 9 in. by 29 ft. On the night of October 31 a large slab 15 ft. by 8 ft. by 3 ft. 6 in. thick, which had been projecting from base of section *H*, fell off, thus leaving the base of *H* a fairly smooth badly discolored surface about 21 ft. by 20 ft.

Section *J* is intact, and for a distance of 110 ft. along the crest is in good condition. At its easterly end there is a step 34 ft. high, and at the bottom of this step the concrete has a horizontal surface, trapezoidal in plan, 21 ft. long and varying in width from 10 ft. to 15 ft. This is a construction joint of nearly 260 sq. ft., and is for the most part quite smooth. It has six $1\frac{1}{4}$-in. square twisted rods projecting 3 ft. from it, but these rods are all bent downstream. It is from this horizontal plane that fragment *H* came. To the east of this place, section *J* is spalled badly, finally terminating in a long low point as described above under the head of section *G*.

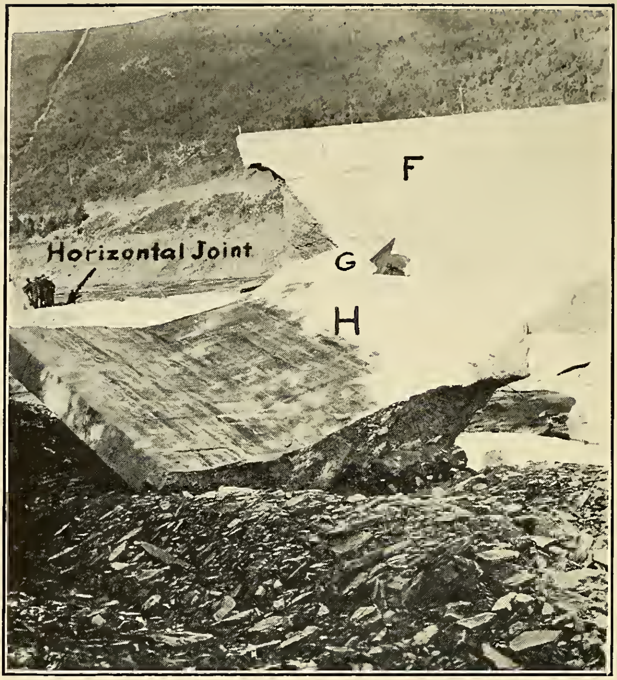
The concrete is for the most part very good, except for the horizontal joints near the west end already discussed, and



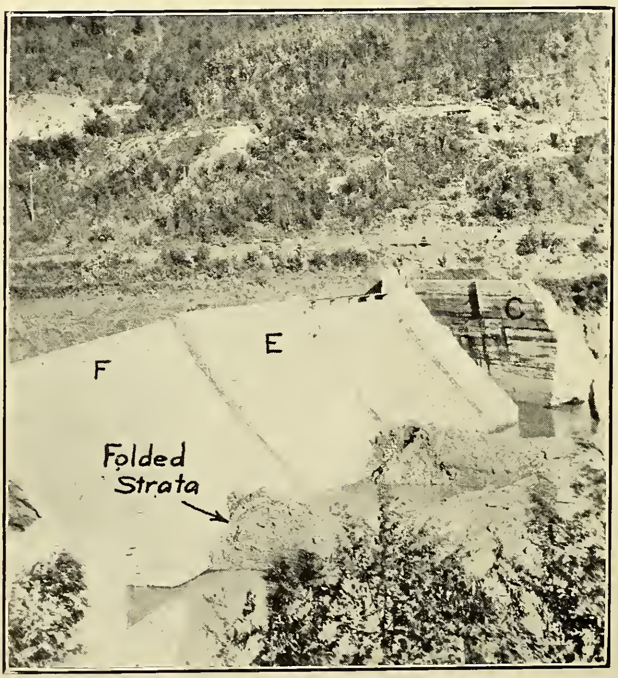
Looking East. Horizontal Joint of J.



Looking Downstream. Fractured Surface of H.



LOOKING UPSTREAM. VIEW SHOWS DOWNSTREAM FACE OF H.



LOOKING EAST. VIEW SHOWS DOWNSTREAM FACE.

for large flat pieces of stratified stone so embedded in the concrete in positions to cause horizontal planes of weakness. Large areas of these horizontal joints are covered with laitance. An experimental determination gives the actual weight of concrete as 152 lb. per cu. ft. There are very few reinforcing rods visible at the fractures. All fractured vertical surfaces except that between sections *A* and *B*, and that between *H* and *J*, are discolored by long contact with water, thus showing that the dam broke into fragments at the old cracks.

On each side of the basin washed out by water flowing between sections *E* and *F* there is a remarkably interesting illustration of the effect of the horizontal pressure due to the motion of these two heavy masses of concrete. As *E* and *F* slid downstream, the thin strata of sandstone and shale were folded upward at the toe of the structure to a height of 10 ft., and the water cutting through this fold left a perfect section of the folded strata exposed to view.

Calculations on the Strength of the Dam.

In the following calculations the ice pressure has been neglected as it is believed that this had nothing to do with the structure in question. In computations the weight of masonry has been taken at 145 lb. per. cu. ft. and the following cases have been considered.

1. Reservoir empty.

2. Reservoir full; with no allowance for upward water pressure on any of the horizontal joints or under the base of the dam.

3. Reservoir full; with allowance for upward water pressure in successive horizontal joints and under the base.

This upward pressure undoubtedly existed at many places under the base of the dam and at such large horizontal construction joints as the one which separated fragment *H* from its supporting fragment *J*.

Case 1. Reservoir empty. Fig. 5 shows that the line of resistance for this case lies outside the middle third of joints *C–D*, *E–F*, and *G–H*, but since the deviation is small and compressions on the joints are not large, no calculations are here shown for this case. It is evident that for reservoir empty the dam was perfectly stable, though it is usual, even in this case, to keep the line of resistance within the middle third.

Case 2. Reservoir full; no upward water pressure within or under the dam. Fig. 5 shows that the line of resistance lies

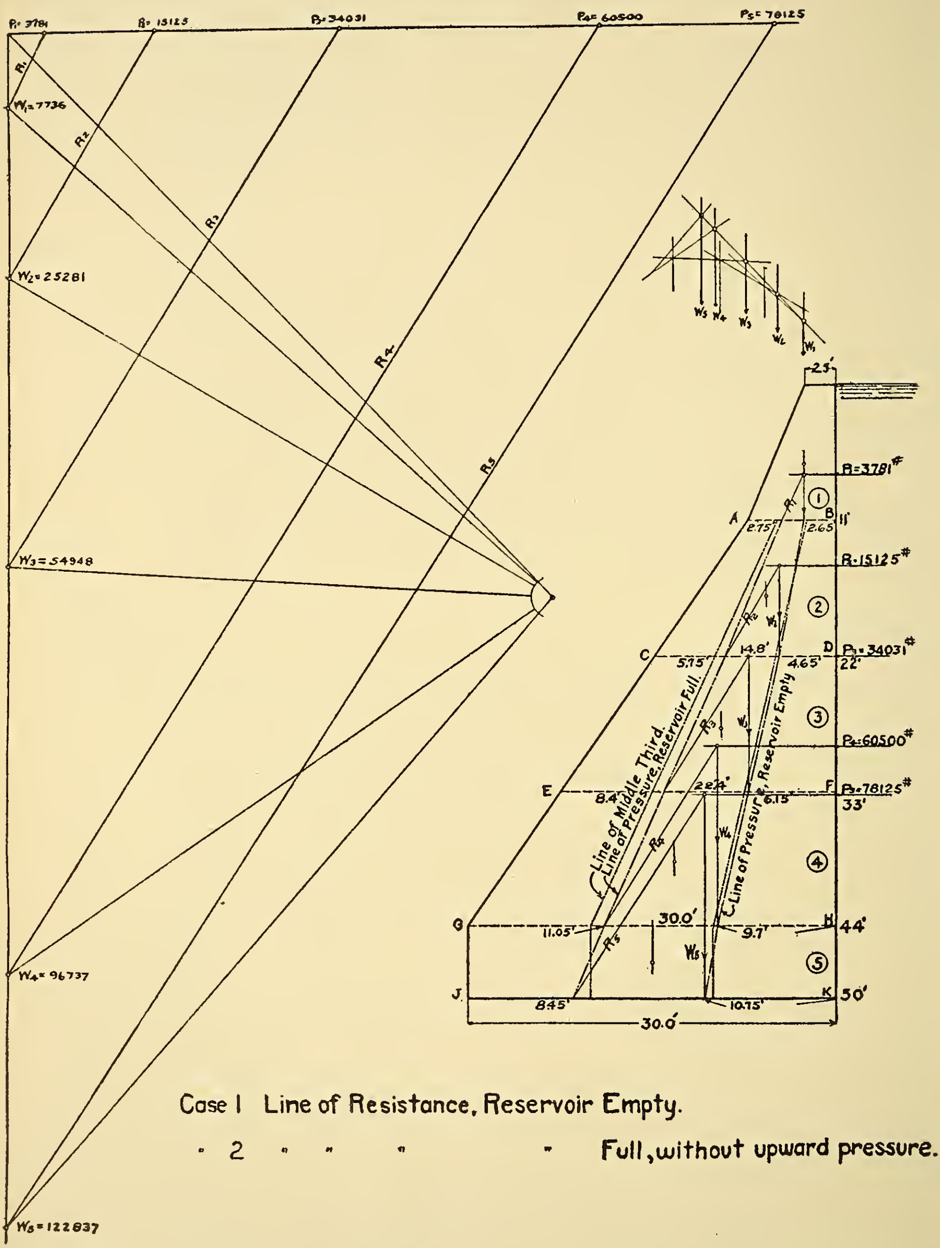

P₁=3781
P₂=15125
P₃=34031
P₄=60500
P₅=78125
W₁=7736
W₂=25281
W₃=54948
W₄=96737
W₅=122837
R₁
R₂
R₃
R₄
R₅
2.5'
P₁=3781#
P₂=15125#
P₃=34031#
P₄=60500#
P₅=78125#
A
B
C
D
E
F
G
H
J
K
11'
22'
33'
44'
50'
2.75'
2.65'
5.15'
14.8'
4.65'
8.4'
22.4'
6.15'
11.05'
30.0'
9.7'
8.45'
10.75'
30.0'
Line of Middle Third.
Line of Pressure, Reservoir Full.
Line of Pressure, Reservoir Empty
Case 1 Line of Resistance, Reservoir Empty.
" 2 " " " " Full, without upward pressure.

FIG. 5.

within the middle third of all joints except J–K, where the resultant force intersects the base 1.55 ft. outside of the middle third, thus indicating tension at the upstream edge, but since there were well-defined separation of materials at the base, no tension could have existed there in the concrete and the joint would be subjected to upward pressure from intrusive water. The effect of vertical anchor rods is here omitted because of poor underlying rock. The resultant should have been kept within the middle third. Computations to check the above point of application of the resultant pressure on the base are given herewith. See Fig. 6. *Mo* is moment in foot-pounds about *o* of all forces above base.

Forces in Pounds.

$$W = 145\ (50)\ 2.5 = 18\ 125$$

$$W_1 = \frac{145\ (11)\ 4.7}{2} = 3\ 750$$

$$W_2 = 145\ (4.7)\ 39 = 26\ 500$$

$$W_3 = \frac{145\ (22.8)\ 33}{2} = 54\ 500$$

$$W_4 = 145\ (6)\ 22.8 = \underline{19\ 850}$$

$$\text{Vertical forces} = 122\ 725$$

$$H = \frac{62.5\ (50)^2}{2} = 78\ 125$$

Mo. Foot-Pounds.

$$78\ 125\ \frac{(50)}{3} = 1\ 302\ 000$$

$$3\ 750\ (2.82) = 10\ 560$$

$$26\ 500\ (3.6) = 95\ 500$$

$$54\ 500\ (13.55) = 738\ 000$$

$$19\ 850\ (17.35) = \underline{345\ 000}$$

$$122\ 725)\underline{2\ 491\ 060}$$

$$20.3 \text{ ft.}$$

$$\underline{1.25}$$

$$21.55$$

$$\underline{20.00}$$

1.55 ft. outside of middle third.

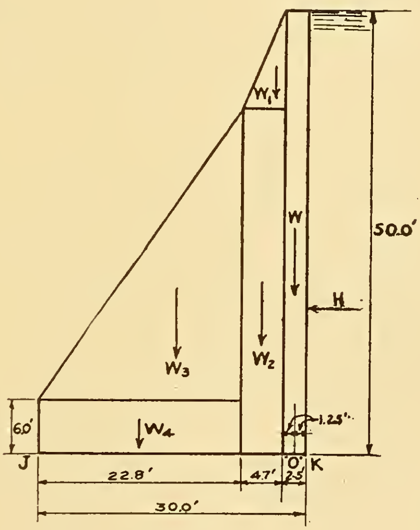


Fig. 6.

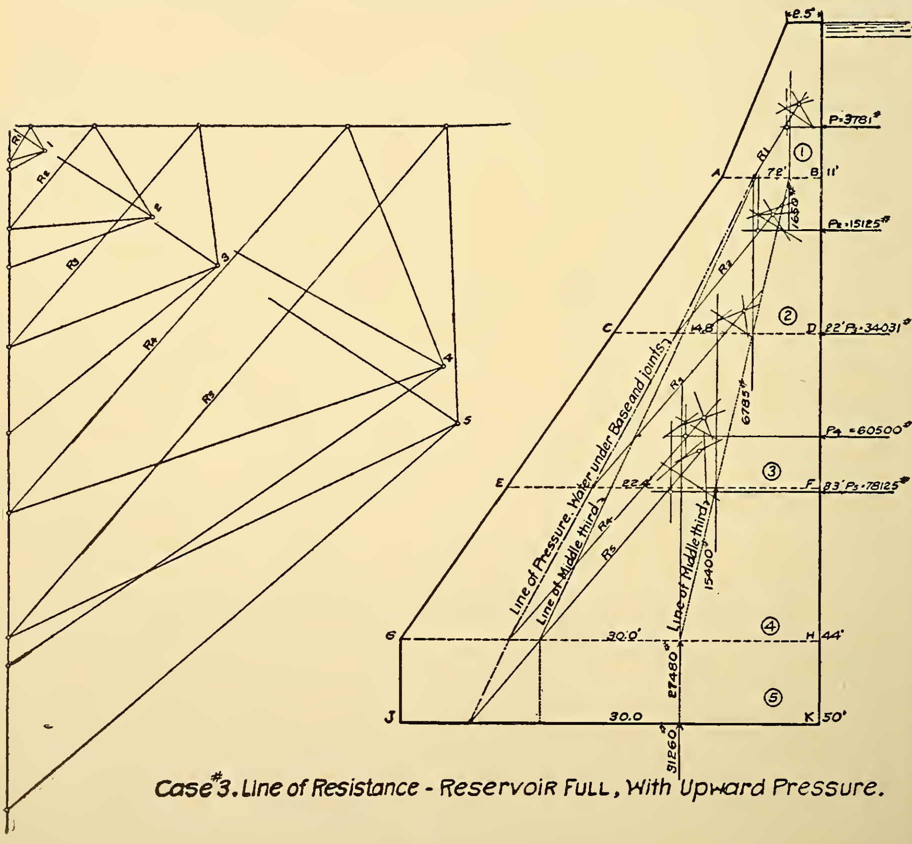
With the resultant acting 1.55 ft. to left of the middle third, or 8.45 from the toe, the maximum compression on the base is as follows:

$$\text{Maximum compression} = \frac{2\ (122\ 725)}{3 \quad 8.45} = 9\ 700 \text{ lb. per sq. ft.}$$

This is equivalent to 67 lb. per sq. in., which for good 1:3:6 concrete is certainly safe.

The only remaining computation on the base necessary for this case is to determine the tangent of the angle between the vertical and the resultant force acting on the base. This tangent is 0.64, obtained by dividing the horizontal force 78 125 by the sum of vertical forces, 122 725, and is the maximum deviation of the resultant from the vertical for all joints for Case 2. It is, however, much less than values for Case 3.

Case 3. Reservoir full; upward water pressure assumed at each joint equal to two thirds the hydrostatic pressure at upstream end and diminishing to zero at downstream end of joint. A word of explanation regarding this assumption is necessary. If water enters a horizontal joint and is not free to escape at the downstream side of the dam, it causes an upward pressure to act which is everywhere equal to the hydrostatic pressure, but if the water can escape, then the pressure will be lessened, especially at the downstream face. If the intrusive water does



Case #3. Line of Resistance - Reservoir Full, With Upward Pressure.

FIG. 7.

not enter a very large area of a joint it is fair to assume in design that the full hydrostatic head does not exist over the entire area, or what is equivalent, that the pressure at the upstream edge of the joint is something less than the full hydrostatic pressure, say, two thirds of that amount, and that at the downstream edge of the joint the pressure is much lower, and it may be zero, as here assumed. Fig. 7 shows the line of resistance lying entirely outside of the middle third, being 5.55 ft. outside at the base. Near the bottom the line is dangerously near the toe, namely, 4.45 ft. therefrom. The above point of application of the resultant on the base is computed as follows:

Sum of downward vertical forces $= 122\ 725$ lb.

Upward water pressure $= \frac{2}{3}(50)(62.5)\frac{30}{2} = 31\ 250$ "

Resultant vertical force $= 91\ 475$ "

$H = 78\ 125$ lb.

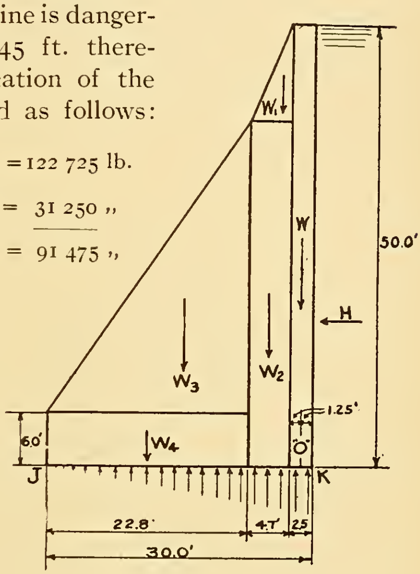


Fig. 8.

	Mo. Foot-Pounds.
From Case 2	= 2 491 060
31 250 (8.75) =	273 000
91 475)	2 218 060
	24.3 ft.
	1.25
	25.55
	20.00
	5.55 ft. outside of middle third,

The maximum compression occurs on the base and is found thus:

$$\text{Maximum compression} = \frac{2\ (91\ 475)}{4.45\ \ (3)} = 13\ 700 \text{ lb. per sq. ft.}$$

This is equivalent to 96 lb. per sq. in., which is certainly not excessive.

The tendency of the dam to slide on any given joint is measured by the tangent of the angle lying between the vertical and the resultant pressure on that joint. For joints *G–H* and *J–K* this tangent is 0.87 and 0.86, respectively, the latter being found by dividing the horizontal force 78 125 by the resultant vertical force, 91 475 lb. This value of 0.87 is far greater than should be allowed even with the very best materials and most careful construction, and would provide no factor of safety for such a case if the base were level. The presence of laitance on the joints must reduce the resistance against sliding, though there are no experiments to show the real effect of this material.

Table 1 gives results of calculations of the joints considered.

TABLE 1.

CALCULATIONS FOR AUSTIN, PA., DAM.

	Distance Down from Crest.	*H.* Lb.	ΣW. Lb.	tan α	Moment at Upstream Edge. Ft. Lb.	X_0 Ft.	Inside or Outside Middle Third. Ft.	Compression. Lb. Sq. In.	Compression. Tons Sq. Ft.
Case 2. (No upward pressure)	11.0	3 780	7 750	0.49	34 100	4.4	In	—	—
	22.0	15 100	25 300	0.60	231 000	9.15	In	—	—
	33.0	34 000	55 100	0.62	775 000	14.1	In	—	—
	44.0	60 500	96 750	0.63	1 835 500	19.0	In	41	2.9
	50.0	78 100	122 700	0.64	2 644 000	21.6	Out–1.6	67	4.9
Case 3. (With upward pressure)	11.0	3 780	6 100	0.62	30 100	4.9	Out–0.1	—	—
	22.0	15 100	18 500	0.82	197 600	10.7	Out–0.8	—	—
	33.0	34 000	39 700	0.86	660 100	16.6	Out–1.7	—	—
	44.0	60 500	69 300	0.87	1 561 000	22.5	Out–2.5	42	3.1
	50.0	78 100	91 500	0.86	2 332 000	25.6	Out–5.6	96	6.9

H = horizontal water pressure above joint in question.
ΣW = sum of vertical forces above joint in question.
tan α = tangent between vertical and resultant pressure on joint.
X_0 = distance from upstream edge of joint to point of application of resultant on joint.

Water weighs 62.5 lb. cu. ft.
Masonry assumed to weigh 145.0 lb. cu. ft.
Slide rule used in calculations.

Width of Base Required to Keep Resultant within Middle Third, Assuming Upward Water Pressure under Base.

It is interesting to see how wide the base must be to make the resultant pass through the downstream middle third point of the base. To determine this width let x be the width of the triangle as shown in Fig. 9, and place the expression for moments about L, the downstream middle third point, equal to zero as shown below. Then solve for x.

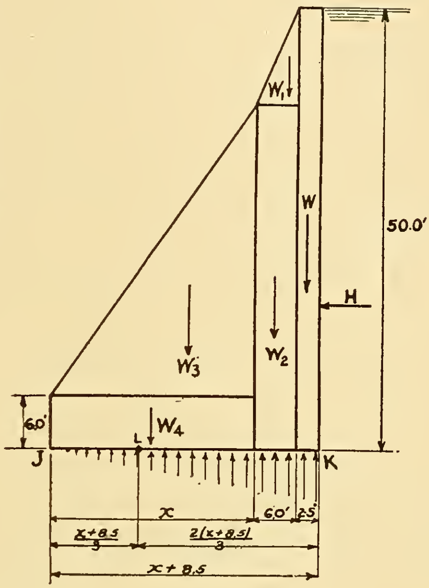


Fig 9

Forces in Pounds.

$$H = 50\ (62.5)\ \frac{50}{2} = 78\ 125$$

$$W = 50\ (2.5)\ (145) = 18\ 125$$

$$W_1 = 11\ \frac{(6)}{2}\ (145) = 4\ 780$$

$$W_2 = 39\ (6)\ (145) = 33\ 950$$

$$W_3 = 33\ \frac{(x)}{2}\ 145 = 2\ 393x$$

$$W_4 = 6\ (x)\ (145) = 870x$$

$$\text{Upward pressure} = 50\ (62.5) \frac{2}{3} \frac{(x+8.5)}{2}$$

$$= 1\ 041x + 8\ 850$$

Equation of Moments about L:

$$-78\ 125\ \frac{(50)}{3} - (1\ 041x + 8\ 850)\ \frac{x+8.5}{3} + 18\ 125\left(\frac{2x}{3} + \frac{17}{3} - 1.25\right) +$$

$$4\ 780\left(\frac{2x}{3} + \frac{17}{3} - 4.5\right) + 33\ 950\left(\frac{2x}{3} + \frac{17}{3} - 5.5\right) + 2\ 393x\left(\frac{2x}{3} - \frac{x}{3} - \frac{8.5}{3}\right) +$$

$$870x\ \left(\frac{x}{2} - \frac{x}{3} - \frac{8.5}{3}\right) = 0.$$

Simplifying: $x^2 + 38.2x = 20.71$. From which $x = 30.3$ ft., and base $= 30.3 + 8.5 = 38.8$ ft., or, say, 39.0 ft., which is the width of base required to prevent tension on the joint when upward pressure acts according to the assumption that this uplift is uniformly varying. And even with this width the tendency to slide is too great to rely entirely on friction, so that

masonry would have to be carried deep to offer proper resistance to the horizontal water pressure. It is clear that the section of the dam as built was far too small.

The Cause of the Failure.

The dam failed by sliding, first at fragment *G*, where all concrete slipped on the underlying strata, and probably immediately thereafter at the horizontal construction joint under fragment *H;* and then fragments *F*, *E*, *D*, *C* and *B* slid forward on the underlying strata. Table 1 shows that the resultant pressures were inclined from the vertical at angles having tangents from 0.82 to 0.87, being a maximum at and near the base. And here lies the cause of the collapse. When water penetrated the joints and the foundations, the dam required a coefficient of friction more than 0.87 to prevent slipping, while the material on which it was placed could offer a coefficient of possibly not over 0.50, and probably not over 0.33. The coefficient of friction of concrete on concrete is probably not over 0.66.

The Influence of Vertical Steel Rods on Sliding.

Fig. 1 shows that rods $1\frac{1}{4}$ by $1\frac{1}{4}$ in. in section and 2 ft. 8 in. on centers were to have been placed as anchorage against sliding and uplift at upstream end of the base. At the horizontal construction joint forming the junction between fragments *H* and *J* there are six of these rods in a length of 21 ft., and on the long point of fragment *J* nine rods are visible. It is very doubtful whether these rods were placed as closely as 2 ft. 8 in. on centers, and even if they had been so placed their effect would have been very small. The shearing strength of vertical rods cannot be developed when gripped between two masses of concrete because of the splitting of the concrete. However, assuming that the rods could have developed their full shearing strength and that they were spaced 2 ft. 8 in. on centers, the following computation is applicable.

Total horizontal force at base	=78 125 lb. per lin. ft. of dam.
Deducting friction = 0.50 (91 475)	=45 728 ,, ,, ,, ,, ,, ,,
Leaving amount to be carried by rods	=32 397 ,, ,, ,, ,, ,, ,,

Each rod carries $\frac{8}{3}$(32 397) = 86 500 lb. total shear, or 55 000 lb. per sq. in.

Hence, even with the large friction coefficient of 0.50, it is seen that each rod must carry 86 500 lb. or 55 000 lb. per sq. in. in shear. This is inconceivable. One who has tested rods in

shear realizes how rigidly they must be held in the grips to make them fail by shear.

Summary of Main Facts.

The failure of this dam is due to sliding as a result of faulty foundation, faulty design, faulty construction and faulty operation.

The material upon which the dam was placed consists of thin layers of shale and sandstone. In at least one place covering an approximate area of 100 sq. ft. this shale is very poor, where a layer varying in thickness from $\frac{1}{4}$ in. to $1\frac{1}{2}$ in. adheres to the upturned bottom of the dam, showing clearly many scratches due to the sliding of the dam. On the other parts of this bottom the concrete is exposed, with none of the thin layers of shale attached to it. This shale is so soft and can offer so little resistance to sliding that the dam slid upon it.

Calculations on and an examination of the wrecked structure show the design of the dam to be faulty in that the base was practically level, was not stepped, and was not carried deep enough to resist sliding, and that proper provisions were not taken to prevent the percolation of water under the dam. The structure shows that in its design no allowance was made for upward water pressure in the joints or under the base and hence the thickness of the dam was entirely too small. In view of the character of the foundation, this is a serious mistake.

Faulty construction in the dam is shown in many places, especially near the western end, where large fairly smooth joints passed horizontally through the structure. These planes of weakness should not have been allowed to exist and are due to the improper method of laying the concrete in large horizontal layers, and allowing one layer to harden before the next was placed upon it. On many of these horizontal construction joints laitance formed and was not removed, thus making the joint less capable of resisting sliding, because of the smoothness and weakness of this laitance. One section of the dam at the west end slid on one of these horizontal construction joints within the concrete at an elevation of 34 ft. below the top of the dam. Furthermore, the large stones placed in the concrete were of such poor material and were so placed in nearly horizontal layers as to weaken the structure's resistance against sliding.

The operation of the structure, i. e., its use after completion, was faulty in that after the dam had once failed by sliding, in January, 1910, water should not, under any circumstances,

have been allowed to collect in the reservoir behind the dam until the latter had been put in a safe condition.

Lessons Emphasized by this Failure.

1. A thorough knowledge of the underlying materials is necessary before a dam can be properly designed or built.

2. No dam should be placed on poor materials consisting of disintegrated or stratified rock without taking proper precautions to prevent water from getting under the base or between the underlying strata, and if such prevention be impossible, and the dam must be built in such a location, then it must be designed with full upward pressure and with large factors of safety against overturning and sliding.

3. Greater emphasis must be laid on sliding as a possible method of failure, and proper precautions must be taken to prevent destruction in this manner. Factors of safety against sliding are frequently taken too small.

4. It is desirable to secure more accurate information concerning the coefficients of friction of various materials and the effect thereon due to wetting of these materials.

5. Upward pressure due to intrusive water should always be assumed in design, and in extreme cases should be taken larger than is now customary; say, equal to the full hydrostatic pressure over the entire area of the base in cases of poor foundations. While this is no doubt unusual, it is necessary, especially since practically all dams leak to a greater or less extent and since only a factor of safety of two against overturning, and one scarcely as large against sliding, are frequently used even when no upward water pressure is considered. For overflow dams the vacuum effect must be allowed for unless eliminated, and in design of dams in cold climates ice pressure must be considered.

6. Greater care should be taken to avoid large horizontal construction joints as well as large vertical planes of weakness so arranged as to reduce their shear carrying power. In this connection it must be realized that in cyclopean masonry the use of large stratified rocks or of any large rocks so placed as to produce horizontal planes of weakness should be carefully avoided. Before depositing concrete on a hardened concrete surface all laitance must be removed and the joint properly prepared.

7. It is important to have competent state supervision of all dams, reservoirs and bridges, which, while not relieving

the owners from their responsibility, will provide an additional safeguard to life and property.

DISCUSSION.

Mr. Frederic P. Stearns. — I think we have all been interested in the graphic description which Professor McKibben has given us of the failure of the Austin Dam and that all will agree with his conclusions as to the causes of the failure. I was pleased to hear him say that in the construction of all dams an allowance should be made for upward water pressure, because some engineers, while they agree that it is necessary to make an allowance for upward water pressure where the foundation is stratified and seamy, do not have the same feeling in regard to rock which is so nearly watertight that only a small quantity of water will find its way through it.

Let us suppose a case where there is a pipe 6 in. in diameter with open ends extending under the base of a dam and another case where there is a pipe only $\frac{1}{8}$ in. in diameter. One would see a great volume of water coming through the 6-in. pipe and a very small quantity of water coming through the $\frac{1}{8}$-in. pipe, but I think no engineer would claim that the pressure against the walls of the two pipes would be materially different; that is to say, there would be the same hydraulic gradient in each.

We quite frequently see the statement made by laymen in the newspapers of the great pressure against a dam on account of the size of the reservoir back of it, while every engineer knows that the pressure against a dam is due to the depth and not to the volume of water against it; but do not engineers in many cases err in regard to the water pressure under a dam in the same way that the layman errs in regard to the pressure against the upstream face? Do they not attribute the amount of upward pressure to the quantity of water passing under the dam, failing to recognize that pressure has practically no relation to quantity? It is my judgment that in designing dams, upward water pressure, both under and in the dam and in the seams in the rock under the dam, should always be included.

It may be argued that the upward pressure is offset in many cases by the tensile strength of the mortar, and no doubt this is true; but in a matter of such importance as the design of a large dam, I believe it advisable to adopt the older amd more conservative view, that one should not take into account the tensile strength of the mortar as an offset to the upward pressure.

We know there are very few dams built which do not permit leakage through the masonry to a greater or less extent, and it is not infrequent that the water comes through some nearly horizontal joint where one day's work has joined another, and especially where one year's work joins another. Such joints may result from the lack of care required to prevent the formation of laitance, but even where the concrete or other masonry is laid with the greatest care upon masonry which has been laid for a considerable time, temperature changes cause movements which produce minute cracks, destroying the bond and permitting the access of water.

If one looks carefully at any large masonry building which has long continuous walls, he will find that many of the stones have small cracks around them and he can trace such cracks through successive joints. I have found similar minute cracks on the downstream face of a masonry dam, and they also exist on the upstream face and permit the water to enter to some extent and produce upward pressure.

I have been interested in what Professor McKibben has said in regard to the sliding of dams, because a great many dams must be constructed where the strata are nearly horizontal and water-bearing seams exist, and the sliding of such dams is the greatest danger. Sometimes such dams can be made safe by cutting down into the rock and building the masonry solidly against the downstream side of the rock cut, but if these dams are spillway dams, floods flowing over them with high velocity may produce pressure in the seams of the rock and displace it so that it will not offer resistance to sliding. In such a case, the safe policy is to add sufficiently to the mass of the dam so that after making due allowance for the upward pressure of the water the friction upon the foundation will be sure to prevent it from sliding.

The subject of dam designing is a very large one, but I will not take the time to mention other features to-night. I think we should feel greatly obliged to Professor McKibben for his clear discussion of the matter.

Mr. Walter H. Sawyer. — I am rather reluctant to express an opinion before so many engineers older than myself and who have had a wider experience. I have been deeply interested in Professor McKibben's paper and, especially, in his conclusions. After making an examination of the dam, I began to doubt the first public statements of the cause of the disaster, and wrote a short article which one of our engineering

papers very kindly published. The early statements in the press and in engineering publications led us to believe that the rock foundation, upon which the dam rested, slid forward, carrying the dam with it, and I believe Professor McKibben quoted such a statement from the *Engineering News*.

When I visited the dam, I saw that parts which had not moved indicated that portions of the dam which had been displaced had slipped on horizontal joints in the masonry itself. These joints were covered with hardened laitance, which I afterwards tested and found to have a resistance to crushing of but from 49 lb. to 288 lb. per sq. in., whereas good concrete, six months old, should not fail much below 3 000 lb. to the sq. in., and I believed that the presence of laitance was one of the causes of the failure. I failed to find the shale which Professor McKibben states was attached to the bottom of one of the pieces of the dam, but he has had an opportunity to make an extended examination and the fact is of importance.

I am very glad to have been present and heard the conclusions, as I understand them, that the dam failed by sliding both on the rock foundation and on horizontal joints.

Mr. Allen Hazen. — I have not seen this dam and have no theories to advance as to the reason of its failure, but I have been greatly interested in the discussion and the clear statements and splendid pictures that we have seen to-night.

The Austin dam is a type of quite a number of dams that we know about, and I think this type has resulted from carrying to a logical conclusion, principles that are to be found in some of the text-books on dam design. It may be true that the men who have written these books and have laid down these principles and have calculated the dimensions which are necessary, have in their own designs always added something to cover other or unknown conditions, and that they have not made designs as light as a strict application of their own principles would indicate; and it may be that others have taken these principles and carried them to their logical conclusion without making the allowances that ought to be made, and now we are seeing one of the results. In other words, the calculation has been made without a proper factor of safety and there are elements which may be important, and in some cases controlling, which have been given but inadequate consideration.

It is interesting to note that the late J. B. Francis, in a paper presented to the American Society of Civil Engineers, Vol. 19, page 147, calculated that the thickness of the base of a masonry

dam to be stable when protected from upward pressure by drainage should be 0.6666 of the height, and when not so protected should be 0.8944 of the height. These were for a specific gravity of masonry of 2.25 in each case. It is interesting to note that Francis' proposed thickness for the drained dam has come to be used by some as the thickness for a dam that is not drained.

The resistance of the dam to sliding is also discussed by Francis, and it may only be noted at this time that the excess of this resistance over the water pressure for the ordinary section is not very great for a comparatively smooth and level bottom, and that upward pressure underneath the dam tends to reduce this resistance to sliding to an important extent.

Mr. W. L. Church. — I do not feel competent to discuss the design of this particular dam, but this much occurs to me after listening to the presentation which has been given of this subject, and it is confirmed by my own experience, — that it is not often that conditions are found which are so difficult as they were here. Nothing causes me so much dread as a stratified or shaly foundation, which seems to have obtained under this particular dam. My own work has led me somewhat away from the solid type of dam, and I do not want you to ask me what I should do if I were to meet a condition precisely like this. I have met such conditions, and it was not a case of "I came, I saw, I conquered," either. If I were compelled to design a dam upon a loose, shaly foundation, particularly if there was a lamination of clay or other lubricating material, I expect the first thing I would do would be to indulge in a season of prayer. Perhaps somebody who is better posted than I can tell me the best way to get in an absolutely reliable and unassailable cut-off wall, for I really think that such a wall is the key to the situation. Explosions of either dynamite or black powder often make a bad matter worse. Such a shale is likely to lift under the gas pressure, and you do not quite know where your shattering effect is going to lead. Can anybody tell me whether we can rely upon getting a sound, substantial and impervious cut-off wall down through the stratification, that is in thin horizontal laminations more or less disintegrated? Would you use a channeling machine so as to get through with the least disturbance? In short, what would you do? I am asking for help, for I shall probably get into this scrape sometime. I am not even prepared to offer my own suggestions at this time. I may have an opinion concealed about my person, but I am not in a state of mind at present where I could offer it with any idea that it would be acceptable either

to you or to myself. But I should certainly make sure — absolutely sure, if there is such a term — as to the integrity of my cut-off section, and after that was accomplished I think I could begin to take some chances. For instance, I might consider perforating the underlying strata and relieving more or less of the water pressure, or other things like that, none of which, however, would have any value until after we had settled this cut-off question. I have had many occasions to build dams on all kinds of foundations, but on none where the foundations might be called absolutely unsafe. I have often built on gravels, Hudson River shales, clay and sand. We have just finished a design to-day which is for a dam wholly on clay, but I want to assure you that the engineer who can take a loose shaly foundation and design a dam with the perfect assurance in advance that he can take care of the cut-off problem is the man I want to meet and shake by the hand cordially and with due humility. I have enjoyed the discussion immensely, and if anybody can tell me anything about this phase of the cut-off problem, he is my friend for life.

Mr. Stearns. — I have had occasion to consider the question of providing a cut-off in stratified rock in connection with two dams in Pennsylvania, and have been well satisfied with the results that have been attained. Both of these dams are earth dams, and in each of them a cut-off trench has been excavated in the rock near the center of the dam down to good material, the excavation being made by hand labor without blasting. Some seams which existed at a considerable depth below the bottom of the cut-off trench were filled with grout forced in under pressure through holes drilled about 8 ft. apart. The cut-off trench was then filled with concrete, which was continued to a height of about 6 ft. above the surface of the rock. This made one line of defense, as nearly water-tight as it was feasible to make it.

As a further precaution, a second line of defense was provided by removing the pervious material above the surface of the rock for a width of about 130 ft. down to nearly impervious material and filling this excavation with the fine impervious earth of which the central portion of the dam was composed. The fine material in the embankment has a still greater width.

In other words, the problem in this case was solved by a cut-off which it was thought would be water-tight, and by a second cut-off which, while it would not be strictly water-tight,

would on account of its great width allow but little water to pass through the dam.

Engineers do not always lay sufficient stress upon the width of a cut-off. If one were to ask an engineer how much water would flow through a pipe with a 100 ft. head, he would at once ask in reply how long is the pipe, knowing that he could not compute the quantity of water which would flow through it without knowing its length as well as the head upon it, but an engineer sometimes speaks of the quantity of water which will leak through a dam 100 ft. high, regardless of the thickness of the impervious portion of the dam. Few materials are absolutely water-tight, and the amount of filtration depends not upon the total head, but upon the relation of the head to the distance through which the water has to filter; that is, the rate of filtration will be the same with a dam 100 ft. high where the water has to filter through nearly impervious material for 100 ft. as with a dam 30 ft. high where the water has to filter through the same material for a width of 30 ft.

Almost any foundation can be made safe if the distance through which the water must filter is made great enough, and this is one way of meeting the problem where it cannot safely be met by a narrow cut-off, no matter how well that cut-off is constructed.

MR. MORRIS KNOWLES. — There is a thought which occurs to me, but I believe there is a written discussion, by Mr. Alfred D. Flinn, which will more thoroughly go into the subject, so I will but touch upon it. There is an evident ethical responsibility upon the engineering profession as a body, in that failures of this kind can go on and that the engineers do not feel called upon to protest in some forcible way.

Some of the recent periodicals, not engineering ones, have commented upon this fact, and have said it is a responsibility that the engineering profession should realize and make a protest, so felt that such failures should not continue without the public having some warning. Many such works are designed by experienced engineers and the plans are carried out and executed by others. Whether this obtained in this particular instance, I do not know, but we all do know of cases where this statement is true. However well thought out a group of plans may be, if some one executes them without a full knowledge of conditions which were in the designer's mind, it is likely that not all the precautions of construction will be taken which are necessary.

There is a very important question as to whether an engineer performs his full public duty in not advising the same public, in case he knows that insecure and unsafe methods are being used, and not in accord with his provisions for the necessities of the case; also, whether a man should sell his design and not have some control over the supervision of the work. Both of these questions are particularly important, where a failure may affect the health or lives of the people. Other public organizations are discussing such questions, and would it not be well that the engineering profession should also face the situation?

Mr. Alfred D. Flinn. (*Read by the Secretary.*) — Technical features of the Austin dam and its failure have been so well described by Professor McKibben, who has given very careful study to the matter, and so much has been printed in the engineering journals, that the writer will not add to the discussion of the subject along these lines. This occurrence, however, and some others which have come to my attention recently, have led to thoughts on the engineer's responsibility to the community, as well as to himself and to his client. Whenever a structure, such as a large dam upstream from a community, can imperil life and property, the engineer has hardly performed his full duty when he permits a client simply to buy from him drawings and specifications. When an engineer enters into such an agreement he loses a very important part of the control of the work, and, in my judgment, does not wholly avoid his moral responsibility to the public for any unfortunate results which may follow improper construction. I believe that in structures of this character, —and they are not limited to dams, — the engineer's engagement with his client should include proper supervision and inspection throughout at least those portions of the construction which would affect the stability of the structure to such a measure that disastrous failure might ensue. He should also insist upon having sufficient authority to carry out entirely safe methods of construction, including proper selection of site and materials.

The proper selection of site for many structures, especially dams and bridge piers, will involve thorough knowledge of conditions beneath the surface, which, in turn, will require core borings or test pits that in many instances will necessitate an expenditure at which a client may be inclined to balk. For the best interests of the client, as well as for those of the community and of the engineering profession, projectors of such structures

should be brought to see that thorough preliminary investigation is not only necessary but wise economy.

It is not sufficient for the engineer to have prepared drawings and specifications which are above reproach, for if the work is not done in accordance with them, and if the unexpected and unforeseeable conditions which may arise during construction are not properly met, partial or complete failure may result, for which, almost unavoidably, the engineer will, in some measure, be held responsible. Therefore, for the protection of the public which reposes confidence in the profession, the engineer, for the protection of his fellow-engineers and for a reasonable measure of self-protection, when undertaking works the failure of which may imperil life and property, should insist upon a sufficient measure of control of the construction.

Mr. H. L. Coburn. — As I sat here listening to Professor McKibben's very interesting description of this wreck and the probable causes, the thought uppermost in my mind has been that this dam must have been designed and built on the reverse plan of that followed by the Deacon in building "The One Hoss Shay," that is to say, "They made the strongest place as weak as the rest."

Speaking seriously, however, I would say that I knew something about the project of building the dam at Austin before the wrecked structure was started; we made a preliminary plan and estimate for the owners, but the project was turned down because our estimate was "too high." Some time after, the matter was put into the hands of Mr. Hatton, and from all I can learn, his instructions were to keep cost down to the minimum, and his services consisted in preparing the plans and did not include supervision of the construction. The whole spirit which prevailed at this time was one of saving every possible dollar of first cost, and I think this is a particularly striking example of false economy.

If there is any class of structure in which the desire to save a few dollars of first cost is more likely to result in ultimate financial loss, to say nothing of danger to life, than dams, I do not know it; and yet even to-day, with the Austin failure fresh in our minds, we are constantly questioned as to the possibility of cutting out a few yards of concrete here or a few pounds of steel somewhere else. To my mind, there can be no justification for "skimping" in any reinforced concrete structure, whether a dam or building. The one great item of cost where

economy can be effected is that of forms, this being especially true in dams and retaining walls.

How such disasters as this one at Austin are to be avoided is perhaps hard to determine, but it is plain that such structures should be built only under intelligent engineering supervision. How to assure this is a problem, but I am confident that it cannot be done through the promulgation of "rules" by state authorities, as they are trying to do in New York state.

I was recently asked by the New York State Inspector of Dams to assist in drawing up some such rules for the buttress type of reinforced concrete dams, and was obliged to decline. I have made some seven or eight hundred designs for such dams at all heights and for all kinds of foundations, and have to confess that even now I am unable to lay down any fixed rules for such structures. Each one is a problem by itself. It is of course possible to fix certain limiting stresses which should not be exceeded, and make a few general requirements as to cut-offs, abutments, capacity of spillways, etc., but beyond this I should hesitate to go. It is certain that every one of the rules recently sent out by the New York State Inspector for buttress dams can be violated without in any way jeopardizing the safety of the structure, provided only the designer knows the fundamental laws of statics and hydraulics. The spacing of buttresses, slope of deck or water-bearing face, slope of crest, slope of downstream face, the minimum thickness of either deck or buttress, are all matters of economical construction rather than safety of structure. For instance, we never make either buttress or deck slab less than one foot thick because we have found that any saving of material below that thickness is more than offset by additional labor in placing steel and concrete.

I would here urge all engineers engaged in designing structures, whether of concrete or other material, to keep constantly in mind a remark attributed to Mr. John Fritz, who, being asked if a certain fly-wheel which he had built was not "stronger than it need be," replied: "I do not know, *and if it is, I never will know.*"

Mr. H. K. Higgins. — There are other structures that we might speak about which are perhaps not usually classified as dams. It once fell to the speaker's lot to look into some questions of water pressure under lock floors and walls. In the final analysis, these are really dams and must be so designed, usually complicated by the necessity of providing for other not less important functions.

The Panama Canal Commission reports for 1907 or 1908 discuss in some detail some of the problems met with at Gatun. The geology of the lock and dam sites was thoroughly studied with both wash and diamond drills.

The borings, many and deep, indicated for the lower part of the work, and below, a fairly homogeneous rock, officially classified as argillaceous sandstone. As the excavation progressed, it was found that the rock was seamy in places, indicating a foundation condition that could not be definitely known till the excavation was nearly complete. Test pits were then sunk and it was found that 6 or 8 ft. below the foundation there were cracks or seams in the rock through which large quantities of water flowed. This flowed into the pits in the form of cascades and occasioned considerable uneasiness. Computations were made to determine the upward pressure under floors of locks and walls, and studies of various schemes were made to determine what should be done to safeguard the structures.

The floors were finally made 20 ft. thick in the forebay below the emergency dam, and were tapered from that to a nominal thickness in the lower lock, with the idea that if the locks were ever emptied and there should be a development of pressure underneath, it would not force up the floor and also it would not damage the walls.

As the pressure was almost 90 ft. head, the 20-ft. layer of concrete would leave an unbalanced upward pressure. In order to provide against that, a large number of rails were set into the ground about 6 ft. apart. Holes were drilled with well drills down to a sufficient depth, 13 to 20 ft. in some cases, so that the rails, which were set vertically in concrete, would be securely anchored, then the floor concrete being deposited around the rails would form a bond so that nothing could rise unless the whole mass of the rock for 15 or 20 ft. below the level of the concrete should rise with it. The rock is fairly homogeneous sandstone with very fine grain; the layers are 6 to 10 ft. thick. It was admitted that the form of construction was expensive, but it was thought wise to take no chances.

-Then this question of cut-off walls came up and they were provided just outside the walls and across under the gate sills so that there should be very little flowage of water. The lower end was left free. The sides of cut-off trenches were cut with channelers, then the rock inside was loosened with light charges of dynamite and taken out with orange-peel buckets.

The undesirability of horizontal joints in concrete has been well brought out in the foregoing paper. That brings up another point in the Panama work. The critics are making a good deal of noise over the high cost of forms at Gatun compared with the Pacific Division, and there is something to be said about that. The concrete at the Atlantic end was designed to be built monolithic from foundation to coping. On account of having to put in water channels there were two or three horizontal joints made; but on the Pacific end the entire wall was built in 6-ft. layers. They may have taken great precaution to get these layers to adhere to each other, but what success they have had can only be determined after the work is tested.

Recurring to the Austin dam, while they may have taken precautions and thought they had obtained monolithic work, they evidently did not, and I think it has been the experience of most of us who have had to do with contractors or foremen, that our efforts are almost sure to be defeated, whenever we try to get really monolithic work. With the number of inspectors that owners are willing to pay for, it is impossible to keep run of mixer and wall at the same time; one or the other must be slighted. As the cement is the item most frequently scamped, that is looked out for and horizontal joints are the unavoidable result. They should, therefore, be allowed for in the strain sheet as the author of this evening's paper has so well said.

Mr. Sawyer. — I believe that I indicated in my published article that, to my mind, the evidence seemed to point to the fact that the failure of the dam was largely on horizontal planes in the concrete between different days' work, and was due to the presence of laitance; that is, this was the fact where horizontal joints could be seen. Some of the horizontal joints, where failure occurred, were under the water at the time of my visit and could not be seen.

Professor McKibben has shown us to-night that one of the pieces of the dam carried with it a thin layer of shale attached to its bottom, so that I have changed my opinion somewhat. I believe now that parts of the dam slid along the upper surface of the foundation rock, other parts on a plane between the upper layer of the foundation rock and the main body of the rock itself; but the larger part slid on joints in the concrete, which were lubricated by the laitance left during construction. Undoubtedly, laitance allowed the water to penetrate to the downstream side of the dam and, probably, the upward pressure on the masonry was nearly equal to that due to the full hydrostatic head.

I tried to make it plain, in my previous statements, that I understood that the opinion in 1910 was that the foundation rock and the dam slid together, but that I do not believe this to be the fact. I have not changed my opinion in that respect, except, as stated above, that a small portion of the dam carried with it a thin layer of shale, which indicates that a small portion of the foundation rock did move with the dam. I believe that if the dam had been properly bonded or keyed to the foundation rock, and that the joints between each succeeding day's work had been properly cleaned and bonded, the dam would have been standing to-day.

The laitance, which can be readily seen on many of the horizontal planes of fracture, varies from one-quarter to four or more inches in thickness. It is very evident that the weakness of this material was not understood, and that it was not removed from older concrete before new concrete was placed. The variation in thickness can be accounted for by the fact that the concrete was poured into the forms at one end, the cream-like mass being pushed forward to the further end of the form, where it formed a deep pool, which afterwards hardened to a substance which took the place of good sound concrete.

I think that Professor McKibben has some samples of laitance here, and it might be interesting if he would crumble some of it before you, so that you may see the material of which a portion of the dam was constructed.

PROFESSOR MCKIBBEN. — I have none of the laitance here. It is very much like chalk in appearance and in texture.

MR. SAWYER. — I have brought some laitance with me [showing some of it]. I was obliged to wrap it in cotton, so as to get it here without injury. You can see how readily it can be crumbled in the fingers.

MR. H. F. TUCKER. — I wish first to express my appreciation of Mr. McKibben's talk to-night on this disaster which has so aroused the engineering profession.

In the various discussions this evening, and in the comments on the failure which I have read, most interest seems to center in the question of water pressure under dams and in the horizontal joints. From the variety of opinions expressed, even among the authorities on dam design, it strikes me that assumption as to such pressure must be purely theoretical.

In designing any engineering structure it is customary to allow a "factor of safety," often to cover assumptions which are

questionable. This "factor" has been called "fool factor," and sometimes "factor of ignorance," but it seems to me it should be a "factor of wisdom." Now in order to make it a "factor of wisdom," in the design of dams, for instance, we ought to go about the matter in a practical way and make some experiments, so that the "factor" may not have to cover our ignorance of the subject of water pressure under and in the dam.

In the Gatun Locks of the Panama Canal, as Mr. Higgins has just stated, there is a cut-off wall which runs across the upper end of the upper locks, just above the emergency dam sill, and down at the rear of the side walls as far as the middle gates. This cut-off wall is about 8 ft. thick, of concrete, and cuts down about 20 ft. at the upper end and about 60 ft. at the lower ends, to what was considered impermeable strata.

This was considered by one of the engineers as sufficient protection against the water of Gatun Lake getting under the lock floors and bursting them upward when a lock was unwatered.

Another of the engineers persuaded those in authority to take the extra precaution of building a floor strong enough to resist water pressure in case the cut-off wall was ineffective. The wisdom of this has since been clearly manifested.

Under these floors a system of drains was laid and connected up to tell-tale wells in the lock walls, so that should percolation develop too great a head under the floors it would be detected and the head reduced by pumping.

During the past dry season measurements were taken in the various tell-tale holes and there were found to exist heads as high as 25 ft. under these floors.

Why would it not be feasible to build similar tell-tale wells in the next masonry dams, and thus determine the pressure at the toe, heel and intermediate points, and even at any horizontal joints that might be made during construction?

It seems to me that this would be a practical way to get at the facts, and to eliminate so much theorizing.

Mr. Higgins. — Perhaps a word might be added to that, — a system of tell-tales was conducted all over that hill where the locks were built; for months it was a certain man's duty to go out and measure the depth of water in all the wells, — he did that all through one season, wet and dry, — the reports give information as to the water levels for a considerable time. It was worked out pretty thoroughly where that water came from. It did not come from the lake. It came from up on the hill.

Mr. W. L. Church. — In building a dam for the Canadian Pacific Railroad which stands upon a bed of clay 15 ft. thick underlaid with sand of indefinite depth, the question of the extent of the base affecting the underflow of water as pointed out by one or two gentlemen came in because, while the dam is only 50 ft. in height, it involves the question of the static pressure of underflow. The point I am making is that the Canadian Pacific engineers, who are very efficient and keen and with any amount of money to spend, are coöperating with us to bring about a series of tests. We are just now discussing whether these tests will be made by vertical pipes carried up above the static line or some form of pressure gage. We are to make a joint endeavor of coöperation with the railroad to find out precisely what takes place as to the general behavior of the underflow. The results of this investigation I may be able to submit to the society, which I shall be glad to do if they are at all conclusive.

Mr. Stearns. — I would like to second the suggestion that it would be well to have some holes drilled through our masonry dams so as to get an actual demonstration of the amount of water pressure that exists in and under them. I have not known of any such tests in the case of masonry dams, but many tests have been made with dams of other material.

In the case of the North Dike of the Wachusett Reservoir, which is a very long earth dam on a somewhat pervious foundation, pipes have been driven into and through the dam at many points in its cross-section, with the result that there is a well-defined hydraulic gradient through the dam. Where an extensive cut-off was built, the slope of the hydraulic gradient is much greater than in other places, but the resistance to flow under this dam is continuous throughout its whole length, and the great width of the dam is an important factor in diminishing the amount of water filtering through it.

A similar hydraulic gradient through earth dams has been found in many cases, but I hope that we shall have some holes put down through some of our masonry dams in order that we may have an actual demonstration of upward water pressure.

Prof. H. K. Barrows. — Professor McKibben has shown clearly in two ways the cause of the failure of the Austin Dam.

First, the photographs and his description of the position and arrangement of the different fragments of the dam after failure indicate that failure was caused by the sliding of a por-

tion of the dam, probably upon a joint in the underlying rock of the foundation. There was also evidently sliding in one or more cases upon horizontal joints between sections of the dam caused by imperfect bonding between successive days' work.

Second, the calculations made by Professor McKibben indicate that the tangent of the angle with the vertical made by the resultant of the forces acting upon the dam was about 0.85. In other words, a coefficient of friction of about 0.85 would have been required to prevent sliding on any horizontal joint, and with a slightly declivity in the rock strata of the foundation even a higher coefficient would have been required for stability. A coefficient of friction of 0.85 is probably equal to or greater than the ultimate value to be expected under the conditions described, and certainly no factor of safety existed in this respect.

There seems to be no question, then, but that the failure was caused by sliding. Whether or not the primary failure occurred by a section of the dam sliding on the foundation, or by sliding upon horizontal joints between successive days' work, cannot be definitely stated. The latter may have occurred subsequent to the sliding of the section of the dam on the foundation.

The inadequacy of data regarding the coefficient of friction of concrete upon rock or of concrete upon concrete, under different degrees of saturation, is manifest, and experiments on a suitable scale and under practical conditions should be made to determine such coefficients. Furthermore, the amount of upward water pressure to be expected under the base of a dam is a factor concerning which much uncertainty exists, and the assumptions made in regard to this factor vary through a very wide range. This is another field where more experimental data are needed.

In the design of concrete overfall dams, in many cases sufficient attention has not been given to the possibility of sliding upon a joint occasioned by poor workmanship. While one criterion of safety in respect to the cross section of a dam consists in keeping the line of resistance within the middle third, a consideration which may be of even more importance is in respect to the angle of slope of this line of resistance, and with dams of moderate height (under about 50 to 70 ft.) it will be found that the section must be designed practically from considerations of stability in respect to sliding; that is, if a section

is safe in respect to sliding, it will be satisfactory as regards position of line of resistance and maximum pressure upon the masonry at any joint. It does not, however, follow that because the line of resistance lies within the middle third the dam will be safe in respect to sliding, although with a very high masonry dam this would probably be the case.

MR. JAMES L. TIGHE. — I would like to ask Professor McKibben how many cubic feet of water per second, per square mile of catchment area contributary to the dam, was the spillway designed to discharge?

PROFESSOR MCKIBBEN. — The spillway was of sufficient size to take care of all the water that has come over it up to the present time, but what the basis of the computation was, I do not know.

MR. TIGHE. — Why I have asked the question is because, if I remember rightly, I think I saw in one of the engineering periodicals that the drainage or catchment area contributary was in the neighborhood of 35 sq. miles, and besides was of a rather precipitous character.

If this were the case, and if the flood flows from that territory are anywise similar in intensity to those from precipitous catchment areas in New England, it had struck me that the spillway of the dam, which I understand was 50 ft. in length and $2\frac{1}{2}$ ft. in depth, was none too large.

While this had no bearing upon the failure of the structure, since there was no overflow from the reservoir when the disaster occurred, yet in making an analysis of the stability of the structure and its factors of safety, the highest head of water that the dam might be subject to in the heaviest phenomenal storms, would of course have to be considered.

From a catchment area of 13 sq. miles, located in western Massachusetts, the maximum run-off, as measured during the past fifteen consecutive years, had an intensity of 183 cu. ft. per second per square mile.

Assuming a run-off from the Austin dam catchment area, similar in intensity to this, it looked to me that under certain favorable conditions, notwithstanding the modifying effect that the reservoir behind the dam would have upon such run-off, the water on the spillway would be more than $2\frac{1}{2}$ ft. in depth. I say this off-handed, simply from my knowledge of the discharge of a reservoir 150 acres in area and having a drainage of 12 sq. miles. The overflow of this reservoir was 25 ft. in length, yet in one of our western Massachusetts storms the

water measured on this overflow 3 ft. 7½ in. in depth, and would have measured still more but it topped the dam at this point.

Wave action and floating ice are things also that should not be too lightly considered when designing dams. One of the best illustrations of one or both of these which has come within the speaker's own personal experience was demonstrated on a small reservoir, having a surface area of only 10 acres, when in a flood storm which occurred in the spring, during the breaking up of the ice on the reservoir, large blocks of ice, one of which measured about 6 ft. in length, 4 ft. in width and 16 in. in thickness, were deposited on the center of the top of the earthen dam, although the maximum height of water in the reservoir at the time did not reach within 2½ ft. of the top of the dam.

Something has been said by previous speakers about text-books sharing in the responsibility of the failure of dams, but that this should not be attributed to college professors, since the three most important text-books on dams in the English language have not been written by professors, but by practitioners.

This may be true, but if the speaker remembers rightly, there is one text-book — (an excellent one at that) — written by a college professor, in which is stated, I think in one of the earlier editions of the work, at least, that if a dam were safe against overturning and crushing, there would be little or no danger from failure by sliding.

It has been the privilege of the speaker to analyze the plans of five or six proposed gravity dams during the past year, relative to their stability, some of which were spillway cyclopean masonry dams of the usual "Ogee" type, running from 45 to 65 ft. in height.

While the analyses of these dams relative to their stability, not considering upward pressure or ice thrust, and assuming the weight of the masonry at 145 lb. per cu. ft. and the coefficient of friction at 65:100, showed a factor of safety against overturning of from 2.4 to 3.2 and a high factor of safety against crushing, yet the analyses showed a very low factor of safety against sliding, this being negative from top to bottom in one of the dams, and not over 1.05 in any of them.

These spillway dams, however, were all subject to high floods. In the case of one of the others, a reservoir dam which I had analyzed, using the same data and assuming the height of the water in the reservoir on a level with the top of the dam, the analysis showed a factor of safety against overturning of 2.44, while the factor of safety against sliding was only 1.13.

Such illustrations, together with what has been said here to-night about upward pressure and ice thrust, certainly suggest that new methods should be taught and followed in future dam designs.

In regard to ice pressure as an argument against the effect of this upon dams, the claim is made that to this cause can be attributed the failure of very few dams.

One reason, perhaps, for this good fortune is that in many cases dams are protected from ice pressure by cutting the ice and keeping an open channel along the face of the dam during the winter months. Were this not done, the probabilities are that a different story would have to be told.

As an instance, I may refer to the masonry dam of the Whiting Street reservoir, one of the distributing reservoirs of the city of Holyoke. This dam has always been protected from ice pressure since it was built in 1889, by keeping the ice cut along its face. In the winter of 1900, however, the cutting of the ice was neglected for some days and the result was that the dam started to leak along the ground line of the masonry for a distance of 400 ft. This leakage, which was very serious at places, was occasioned by some movement in the dam, caused by the ice pressure, because when the ice was cut along the dam and the pressure relieved, most of the leakage stopped. The dam was repaired and made safe at a large expense by backing up the water-side of it with gravel. It is needless to say that the cutting of the ice along the dam has never been neglected since.

Now, is it not safe to infer that other masonry dams are protected from ice thrust in the same manner as this is at Holyoke, and that, therefore, so many dams are not actually exposed to ice pressure as might be expected?

Mr. E. M. Blake. — Perhaps the members of the society will be interested in a few words with regard to the new impounding dam now being constucted by the United States Reclamation Service on the Boise River in Idaho. It is only by living in the arid west and becoming familiar with the magnitude of the engineering problems encountered there that one can fully realize the splendid work being done by the Reclamation Service. During the three years which I have just spent in that state on irrigation and power work, I have had the pleasure of meeting many of the Reclamation Service engineers in each of the government irrigation projects. One of the men whom it was my pleasure to meet was Mr. Charles H. Paul, formerly of Malden, and who was connected with the original surveys for the

improvement of the Neponset River in 1895. Mr. Paul is now engineer in charge of construction of the Arrow Rock dam located in the canyon of the Boise River. This dam is to impound over 200 000 acre-feet of water for the Boise irrigation project. If the present plans are carried out, it will be the highest masonry dam in the world, being 351 ft. from bottom of foundation to crest and containing over 500 000 cu. yd. of cyclopean concrete masonry. At the October, 1911, meeting of the Idaho Society of Engineers, Mr. Paul presented a paper on the Arrow Rock dam and exhibited the plans proposed at that time for its design. These plans will very likely be modified before construction, but they covered in general the design. While the dam will be of the arch type, it will be built with a gravity section heavy enough to withstand the maximum water pressure, and in addition to having an adequate high level spillway, will be provided with a discharge tunnel through the rim rock on one side of the canyon for drawing off the water for use in the government canals below, as well as the many private canals having water rights in the Boise River. The point which I wish to call particularly to your attention in connection with the excellent paper just presented by Professor McKibben on the Austin dam is the fact that the Arrow Rock dam is to be provided with an adequate seepage tunnel running across the dam in a line with its axis at a low level. By means of this seepage tunnel it is expected that all water finding its way up, through or along the foundations, will be intercepted and carried off through an outlet downstream.

Professor McKibben. — There is one other thing that I think has not been discussed here to-night, and that is state supervision of the construction and operation of dams. Certain corporation engineers claim that the state should exercise no supervision over the construction or operation of privately owned dams. Other engineers held the view that the state should exercise some control, but should not of course take the responsibility. I believe the proper ground is between these two. But in the consideration of the state supervision of the design, construction and operation of masonry dams, an important question immediately comes up. Suppose that a competent state engineer has passed upon and approved a plan for a masonry dam. Then comes the question of the construction of that dam. In order to be sure that it is safe the state engineer must know something about the construction of the dam at certain critical stages. Therefore, it would be necessary under such a scheme for the

state to have a competent engineer or inspector at the dam at certain important stages.

Unless the state appropriates a sufficient sum to secure capable men, such a system would fail. Then after the dam is finished, supposing it to be finished in accordance with the plan and properly constructed, there should be certain examinations from time to time by competent engineers in the employ of the owner, who would submit reports to the state upon its condition, say, at intervals of perhaps two years, and from time to time the state engineer would examine the structure. We would have then the supervision of design, construction and operation by a competent state engineer.

Mr. Blake. — The Carey Act was passed by the government in order to make it possible for private capital to irrigate and reclaim large and small areas of arid land for the same general purposes as were covered by the earlier Reclamation Act. I think it is safe to state that the Carey Act has been taken advantage of to a greater extent in Idaho than in any other of the arid states. Over three million acres of the public domain have already been set aside by the government for reclamation under the Carey Act in Idaho alone, which is a larger area than all of the government reclamation service projects combined. A large percentage of these three million acres is already covered by constructed canals and plans are under way to cover the balance. The Carey Act provides that all projects developed under it shall be under the control of the individual states the approval of whose land boards and state engineers must be obtained in the design and construction of all canals, dams, reservoirs and ditches. Each state in which the Carey Act is used by private capital has passed its own particular acts and regulations for the control of that work within its borders, and these acts vary considerably in the different states. I have seen the Carey Act and state laws concerning the same in operation during the last three years under the supervision of the State Engineers' office in Oregon and Idaho. The methods used in this supervision are changed and improved every year, but as the thoroughness with which this work can be done is dependent upon appropriations for the State Engineers' office, it is not always possible for the State Engineers' office to carry out this work of supervision even to the extent to which the State Engineers themselves urge and recommend it. Particularly is this true with regard to the daily inspection of construction work on the canals and impounding dams. During my

first two years in Idaho, four inspectors connected with the State Engineers' office were assigned to the various Carey Act projects under construction, but did not put their time consecutively upon any one project. In the fall of 1910, I received the appointment from the governor and State Land Board of Idaho, to make a thorough inspection of the entire project of the Twin Falls North Side Land and Water Company, irrigating 220 000 acres of land through about 550 miles of main canal and laterals, with two storage reservoir dams under construction. I had forty-two assistants on this work from November, 1910, to March, 1911. We placed an inspector at once on each of the two dams under construction. At this time also, and during 1911, outside of the above force, the State Engineer had four other inspectors located permanently on various construction work. The lack of adequate appropriation for this class of work is constantly being brought to the attention of the legislatures in the arid states, and much of the trouble which has arisen in the past from lack of thorough inspection by the state during construction will not be repeated in the future.

[NOTE. — Further discussion of this paper is invited, to be received by Fred. Brooks, Secretary, 31 Milk Street, Boston, by August 1, 1912, for publication in a subsequent number of the JOURNAL.]

DISCUSSION OF PAPER "THE SANITATION OF CONTRACTORS' CAMPS AND THE PATROL OF WATERSHEDS."

(VOLUME XLVIII, PAGE 97, MARCH, 1912.)

LABOR CAMP SANITATION AT THE PITTSBURGH FILTRATION WORKS.

MR. MORRIS KNOWLES. — The filtration system of the city of Pittsburgh, built during the years 1905–1909, is located on the north bank of the Allegheny River, at a point about seven miles above its junction with the Monongahela River to form the Ohio River. It occupies a tract of approximately two hundred acres in extent, with a river frontage of 3 700 ft.

The territory on both sides of the Allegheny River is thickly populated, and down stream from the land which was then allotted to the contractor for his camps, numerous intakes secure water for both domestic and industrial water supplies. Directly adjacent to the filtration site, and down stream from it, are located the drilled wells from which the borough of Aspinwall is supplied. Opposite these and about midchannel, there was located the intake crib, from which peninsular Pittsburgh was then obtaining its entire water supply. Still further down stream are the water supplies for Sharpburg, Etna, Milvale and part of the former city of Allegheny, as well as other intakes below Pittsburgh on the Ohio River.

In all, about 420 000 persons secured their domestic supply of water at that time from the Allegheny River, between the point chosen for the Filtration Works and the junction with the Monongahela River. In addition, many industrial concerns had their source of water supply in this section of the river. Some of these establishments manufactured foodstuffs. Generally speaking, the drinking and washing supply of water in these industrial places was unpurified Allegheny River water.

Those conditions caused an early appreciation of the danger from the common type of construction camps and that care must be exercised in the management and regulation of the living and sanitary conduct of the workmen employed on this work. Sad indeed would have been the result if, in building such works for purifying the city's water supply, we should ourselves have contaminated the existing sources and brought about an epidemic. Some recent deplorable experiences from the careless

conduct of railway construction camps near the city, both as regards lawlessness and lack of sanitary control, had served to impress the necessity more firmly in the official mind. The importance of these things was the subject of many conferences of the writer with his assistants and with friends engaged upon like work elsewhere. The great similarity of many of the Pittsburgh clauses with those of the reservoir contracts of the Croton Aqueduct Commission's work shows the result of several talks with Mr. A. D. Flinn, now engineer in charge of the Head-Quarters Department of the New York Board of Water Supply, who was then preparing specifications for the above-mentioned reservoir contracts, which were issued a little later.

When writing the specifications for Pittsburgh contracts, in 1904, considerable space was dedicated, in the "General Clauses," to sanitation and the regulation of camps and living conditions. This was two years prior to the execution of similar contracts with similar provisions upon the New York Board of Water Supply work. The Pittsburgh specifications covered this subject in a thorough manner, taking up each of the various main features in a section. Some of the more important ones are quoted herewith:

Section 27: Land to be occupied. This section allotted to the contractor about 20 acres of ground owned by the city, to be used for labor and camp outfit.

Section 28: Buildings for Men and Animals. "The building of tents, shanties, barracks, or other buildings or structures for housing the men and animals will be permitted only at such places as the director shall approve; and the sanitary condition of the shanties or other structures and of the grounds about them shall at all times be maintained in a manner satisfactory to him."

"Each and every dwelling or building used as sleeping quarters or occupied by employees or laborers engaged upon the work shall contain at least three hundred cubic feet of air space for each and every occupant thereof. Each such building shall be ten feet high in its lowest part and shall be provided with tight floor, which shall be raised upon supports and set at least one foot from the ground. Each such building shall be provided with proper and suitable means for ventilation and lighting, and all windows and openings shall be constructed so that they can be readily opened. If such buildings are heated, suitable precautions shall be taken to prevent fire, and the spread of fire, should such occur."

"Each and every camp for the housing of men and laborers shall be provided with a separate building to be used as a wash house or laundry, and also with a separate building constructed and set apart for use as a kitchen or cookroom. Each and every stable for housing horses, mules, cattle or other animals employed upon the work shall be situated at least one hundred and fifty feet distant from the nearest point of any dwelling, barracks or kitchen used by or for the laborers or workmen; and storage and disposal of manure

shall be properly cared for, so as to be sanitary and not unhealthful or unsightly."

"The location of any and all such buildings and of any camp shall be made with due regard to its healthfulness and that it may be thoroughly underdrained, and any camps proving to be unhealthful, or wanting or lacking in any of the above particulars, or unsanitary in any way, shall be promptly remedied, and in case of failure so to do, the director shall have the right to order such camps abandoned and other camps constructed and suitable provision made for the sanitary and proper housing of the laborers."

Section 29: Sanitary Regulations. "The contractor shall supply sufficient potable drinking water to all of his employees, but from such source or sources only as are approved by the directors. In case such source or water supply is contaminated or unhealthful for any reason, the contractor shall desist in supplying his men from such source or sources and immediately provide pure water from a suitable source, or else furnish suitable and approved means for purifying the water from such supply."

"Food, table and kitchen waste, or garbage and all such refuse, liquid or solid, shall be immediately placed in a tight receptacle of sufficient capacity to keep the usual day's supply, and at least once in twenty-four hours all such wastes shall be incinerated or burned, and thus thoroughly disposed of, so as not to create a nuisance anywhere."

"Sanitary conveniences for the use of all men and laborers employed on the work, properly secluded from public observation, shall be constructed and maintained by the contractor in sufficient number, in such manner and at such points as shall be approved by the director, and they shall be exclusively used by all workmen and laborers, and sanitary maintenance of which shall be strictly enforced. These sanitaries shall be constructed upon the septic tank principle, with tight container, and shall be properly arranged with flushing devices, so that septic action can take place, and the liquid running away shall be reasonably clear, colorless, free from disagreeable odors, and entirely unobjectionable to allow to run to a water course; or other satisfactory design of sanitary will be allowed subject to the approval of the director."

Section 30: Medical Inspection. "The contractor shall contract with one or more qualified medical practitioners, situated in Allegheny County, Pennsylvania, for the medical and sanitary supervision of their employees and works, who shall have care of and inspect all dwellings, stables, sanitaries and works at least once a week, and oftener if the health condition of any camps or such provisions require it, and supply attendance and medicines to all workmen and employees."

"The contractor shall furnish each week a list of all new men employed upon the work from the date of the previous list and a properly certified statement, or certificate by the medical officer in charge, that each such employee has had a recent successful vaccination; no man shall be employed upon this work in any capacity whatsoever without such certificate, or without having been vaccinated at the time of his employment."

"Should any suspected contagious, infectious or communicable diseases break out in any of the camps, works or dwellings, the contractor shall at once have the person so taken ill removed from the premises and entirely away from the work and land occupied by the camps and shall at once notify the inspector, and also the State Board of Health, or its properly authorized officer, of such outbreak. The contractor shall either provide and maintain

a properly constructed contagious disease hospital large enough to accommodate at least one tenth of the full number of employees, or, in lieu therefor, shall contract with one or more of the hospitals in Allegheny County to take care of any of his workmen or employees who may become ill with any disease necessitating his removal from the camps."

The various acts of Assembly and rules and regulations of the State Board of Health were to be considered a part of the contract. Particular attention was called to Circular 57, "Regulations for the Sanitary Construction, Management, and Control of Industrial Camps."

Section 31: Emergency Hospital. This section required an Emergency Hospital and all the necessary equipment, up to the standard of an army field hospital, capable of rendering first aid to the injured.

Section 32: Intoxicants. This section called attention to existing state laws for the regulations of the sale of intoxicants, and prohibited such sale in the camps. Policing was therefore required of the contractor.

The actual construction work on the Pittsburgh Filtration System, costing, with the appurtenant work, about $6 000 000, and employing 1 000 men at times, was started in the early part of 1905, and the specifications above cited were at once put into effect. The engineering department of the New York Board of Water Supply was organized about June, 1905, and the first contract was signed in 1906. In fact, Mr. Thomas H. Wiggin, who was Principal Division Engineer, in charge of the construction field office of the Pittsburgh Bureau of Filtration, was at an early date appointed to the headquarters department of the engineering staff of the Board of Water Supply and had much to do with the specifications first adopted for the New York work.

The important difference between the two undertakings in this respect was one of operative policy. The cost of such measures necessary to this control in Pittsburgh was considered as an overhead charge to be divided over all items of work. Upon the New York work, however, beginning with contracts let during the season of 1909, the contractors were paid a specified amount for several of the items of such work of sanitation. The experience gained at Pittsburgh indicated that the policy of having a definitely itemized payment as the work is completed is better; for this removes any incentive to shirk doing such important details and taking such necessary precautions. The economic advantages resulting from proper living and sanitary conditions in labor camps are that increased stability and reliability of labor and greater efficiency of the individual laborer are secured. That such can be attained by improved environment, no one can doubt who contrasts his own effectiveness under conditions of impaired health, unfavorable surroundings

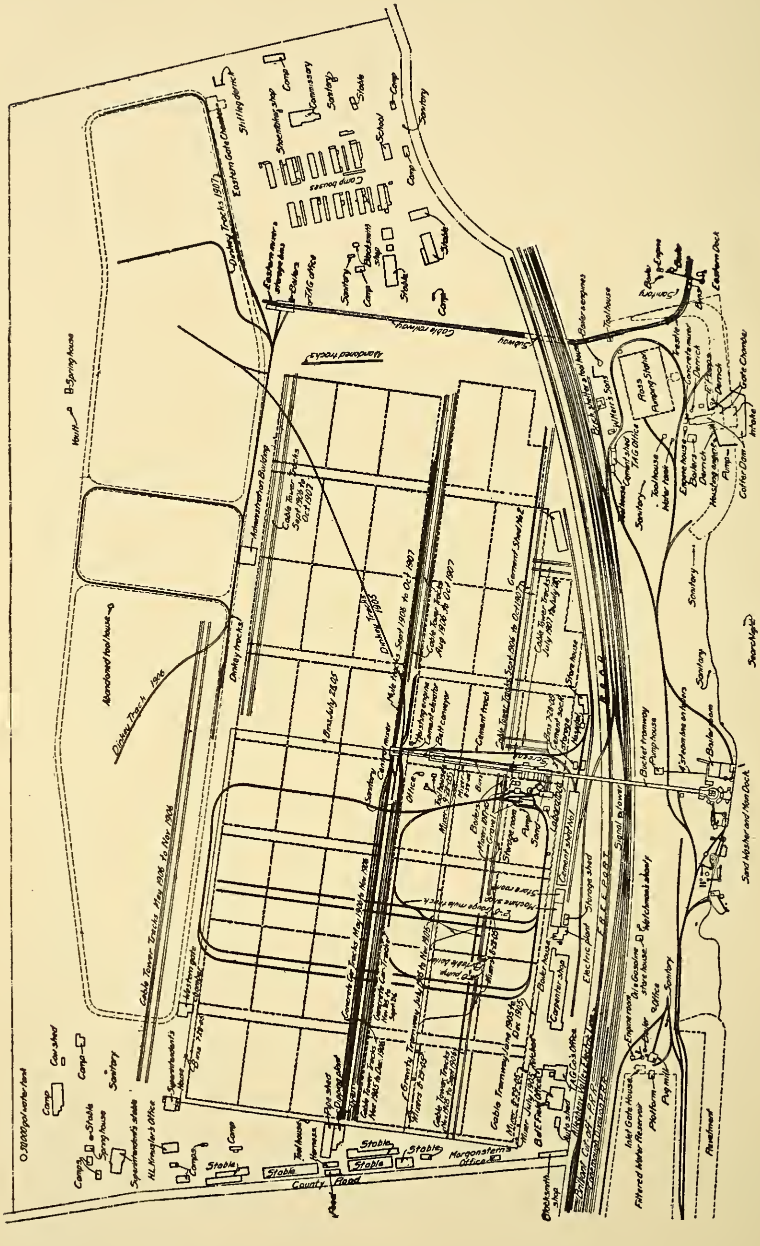


PLATE I. GENERAL LAYOUT OF CONTRACTOR'S PLANT AND CAMP, PITTSBURGH FILTRATION WORKS.

or discontent with that under the contrary conditions. Although it is true that it pays to conserve the health and welfare of the laboring force, yet it is hard to convince a contractor that this is so. The doing of such humane things comes with much better grace if there is not the occasion to doubt if such expenditure is necessary to produce efficiency, and to look upon it as money wasted without return.

It is gratifying, however, to note progress along this line; for within the last few years, since these works were begun, many employers of labor on construction work at mines, lumber camps, etc., have realized that such care of the men and their families really pays. The placing of such work under the guidance and control of an executive force, not troubled with the responsibility of output and outside of the operating branch, is sure to result in the more efficient and thorough accomplishment.

Plate I shows the general layout of the contractor's plant at Pittsburgh, including camps. The laborers' quarters were located at the extreme easterly end of the property, and the stables at the extreme west. The hospital was located near the center of the work, so as to be readily accessible.

The supervision of this work, for the city, was assigned to the "Division of Inspection and Sanitation," which was in charge of Mr. Wm. R. Copeland, whose previous training, energetic activities and sane understanding of matters of real sanitary importance brought about a vigorous endeavor to enforce the provisions of the specifications. In addition to several earth closets about the work, seven septic tank sanitaries were installed, located at secluded yet easily accessible places. The liquid from these was sterilized and carried through sewers to the river and the effluent was quite unobjectionable. The drinking water supply was obtained from wells and springs, the water being analyzed often enough to detect the evidences of pollution and to prevent the spread of disease from such sources.

The greatest difficulty was experienced in the endeavor to have the kitchen waste and general refuse disposed of by burning. Unclean habits of the American laboring classes are extremely troublesome to modify, and much remained to be done. Much, however, was accomplished in this line by completely cutting all weeds and underbrush in the vicinity, which otherwise served as convenient shields for deposition of all sorts of personal and camp waste.

In all respects and considering the then state of opinion as to these matters and the method of payment, we were reasonably

successful. The camps presented a fairly clean and wholesome appearance, being in advance of those which had usually obtained upon construction work of this character. There was but little disease, and a very small amount of an infectious and contagious character. The few suspected cases were promptly removed to hospitals. The total amount of typhoid fever was 32 reported cases during the history of the work of three years, a very good record. No epidemic occurred here or in the adjoining boroughs or cities traceable to these operations on the bank of the main source of water supply for all.

Mr. T. H. Wiggin (*by letter*). — In connection with the author's excellent description of the sanitary precautions taken in constructing the Catskill water system, a brief review of the history of such provisions may not be without interest. The nucleus may be found in specifications for the large Metropolitan Water Works of Massachusetts, the influence of which was extended to Pittsburgh, New York, and elsewhere, due to the employment in the latter places of men from the former work. The gradual development of the sanitary specifications will be evident from the following quotations taken in historical order:

The Aqueduct Commissioners, New Croton dam; specifications dated 1892. No special sanitary specifications.

Metropolitan Water and Sewerage Board, Wachusett aqueduct; specifications dated 1896. These in general had no sanitary provisions, but Contract 37, for the open channel, had the following:

"*Sanitary regulations.* The contractor shall adopt and enforce promptly and fully such sanitary regulations in regard to the construction and maintenence of privies for his men, or arrangement of his shanties, as may be directed by the engineer."

Metropolitan Water and Sewerage Board, Wachusett dam; specifications dated 1900:

"*Sanitary regulations.* Necessary sanitary conveniences for the use of laborers on the work, properly secluded from public observation, shall be constructed and maintained by the contractor in such manner and at such points as shall be approved by the engineer, and their use shall be strictly enforced. The sanitary condition of the shanties and other structures used by him and of the grounds about them must at all times be maintained in a manner satisfactory to the engineer. The contractor shall obey and enforce such other sanitary regulations and orders as the engineer may deem necessary."

"*Clearing up.* On or before the completion of the work . . . shall remove all organic matter and material containing organic matter in, under and around cesspools, privies, stables, houses and other buildings used by him and located within and for 50 ft. outside of the limits of the reservoir. . . ."

"*Purity of water.* The contractor shall take special care to avoid polluting or otherwise injuring the quality of the water which is to flow through the aqueduct or the 24-in. pipe. He shall dump earth into the water above the dam only at the place marked 'Site for spoil bank' on plans Nos. 1 and 2, and at such other places as the engineer may permit or direct, and all earth so dumped shall be protected by facing the slopes which may be exposed to the water with stone; shall dispose of dirty water pumped or otherwise removed from the excavations so that it will not mingle with the water above the dam, and shall do such other work as the engineer may deem necessary to prevent such pollution or injury. All of the aforesaid work for the protection of the purity of the water shall be done without charge therefor."

Metropolitan Water and Sewerage Board, Weston aqueduct; specifications dated 1901:

"*Sanitary regulations.* Necessary sanitary conveniences for the use of laborers on the work, properly secluded from public observation, shall be constructed and maintained by the contractor in such manner and at such points as shall be approved by the engineer, and their use shall be strictly enforced.

"*Shanties.* The building of shanties or other structures for housing the men will be permitted only at such places as the engineer may approve, and the sanitary condition of the grounds in or about such shanties or other structures must at all times be maintained in a manner satisfactory to the engineer."

"*Clearing up.* On or before the completion of the work, the contractor shall . . . remove all organic matter and material containing organic matter in, under and around cesspools, privies, stables and other buildings which he has erected or occupied. . . ."

Metropolitan Water and Sewerage Board, Lake Cochituate improvements; specifications dated 1901: The sanitary specifications are the same as for Weston aqueduct with the following addition:

"*Sanitary regulations.* They [conveniences] shall be maintained under the most rigid sanitary rules and inspection, in order to protect the purity of the water of Lake Cochituate.

"Any privies used in the bottom of the meadow shall have water-tight receptacles of galvanized iron, the use of which shall be strictly enforced; and these shall be removed when full and their contents buried at points designated by the engineer."

City of Pittsburgh, Bureau of Filtration, plant at Aspinwall, Pa. Advertised February, 1905. The discussion by Mr. Knowles will cover this fully.

The Aqueduct Commissioners, Cross River reservoir; specifications dated May, 1905.

"*Sanitary protection of river and reservoir.* The site of the work covered by this contract is immediately above an arm of the new Croton reservoir, into which the Cross River flows. The waters of this reservoir and of the Cross River are now being

used by the city, and therefore every reasonable precaution must be taken by the contractor to prevent their contamination by himself or his employees. These precautions shall at all times be satisfactory to the chief engineer, to the Department of Water Supply, Gas and Electricity, and the Department of Health of the City of New York, and to the State Board of Health. The contractor shall promptly and fully comply with all orders and regulations relating to the sanitary protection of the water supply."

"*Contractors' camps.* Suitable buildings satisfactory to the engineer shall be provided by the contractor for the housing, feeding and sanitary necessities of the men, and suitable stabling for the animals, employed upon the work. Such buildings shall be located at places satisfactory to the engineer. The stables shall be at an approved distance from the laborers' quarters.

"*Water supply and garbage destruction.* The contractor shall supply sufficient drinking water of good quality to all of his employees. Garbage, both liquid and solid, shall be promptly removed from the buildings and immediately placed in approved tight receptacles of sufficient capacity for about one day's ordinary production, and at least once in twenty-four hours all such garbage shall be incinerated or otherwise thoroughly disposed of to the satisfaction of the engineer, so as not to create a nuisance."

"*Sanitary conveniences and sewage disposal.* Sanitary conveniences for the use of all persons employed on the work shall be constructed and maintained by the contractor in sufficient number in such manner and at such places as shall be approved by the engineer. All persons connected with the works shall be obliged to use these conveniences. If required by the engineer, the contractor shall build the sanitaries on the septic tank principle so as to yield a reasonably clear effluent, free from disagreeable odor and of such quality that it may be permitted to flow over the land into the water courses, or, through an approved sand filter, into the reservoir."

"*Medical attendance and inspection.* The contractor shall retain the services of one or more qualified medical practitioners, who shall have the care of the laborers, shall inspect their dwellings, the stables and the sanitaries at least once a week, and oftener if the health conditions of any camp shall make more frequent inspections desirable, and shall supply medical attendance and medicine to the employees of the contractor whenever needed. Any employee of the contractor who shall be found to have a contagious or infectious disease shall be at once removed from the camp and from the limits of the Croton watershed, and the contractor shall make arrangements with a suitable hospital to care for such cases. The contractor shall give the engineer satisfactory assurance that the above medical and hospital arrangements have been made."

There is evidence in the older specifications of a lively appreciation of the influence of sanitary conveniences and properly

maintained shanties on the sanitary conditions. The Pittsburgh specifications were the first of those cited to contain the more elaborate provisions with respect to medical examination, separation of animals and cooking from sleeping quarters, purification of wastes, incineration of garbage, etc. The Cross River specifications of the New York Aqueduct Commissioners were being worked upon at the same time as, or a few months later than, the Pittsburgh specifications, and contain substantially the same provisions, in many cases in very similar wording, showing the results of conferences of Messrs. Flinn and Knowles. The Board of Water Supply specifications for the earlier contracts were largely clipped from the Cross River specifications. When it came to drafting specifications for the Board of Water Supply contracts, which covered work to be constructed within the Croton watershed, even more elaborate precautions suggested themselves to the writer's force, which was charged with the preparation of the first of these contracts. Mr. Leonard P. Wood suggested fencing the camp areas, putting a ditch around them and around tunnel spoil banks, and providing storage basins and filtration plants for the treatment of the surface drainage from these camp sites, from tunnels and from tunnel spoil banks. The writer, in forwarding these suggestions with approval, recommended, as a lesson from his Pittsburgh experience, the payment for sanitary works under items instead of covering them in the overhead charges. This method of payment was distinctly in accordance with the general policy of Chief Engineer J. Waldo Smith, and was adopted. At the same time the writer recommended securing advice from a sanitary expert on account of the very grave importance of sanitation on the Croton watershed. Department Engineer Alfred D. Flinn took the sanitary specifications actively in charge and elaborated them with the advice of officials of the Croton system and sanitary experts in the employ of the city and in private practice. When construction was about to begin on the tracts within the Croton watershed, the Board of Water Supply appointed its sanitary expert, not only to advise on these important contracts, but also to supervise the carrying out of the sanitary provisions on all the work.

Many of the subsequent contracts affected water supplies in Westchester County and elsewhere, and specifications were fitted by the writer to the peculiar requirements with the advice of the Board of Water Supply sanitary experts. In all of these special cases the burning of excreta, as derived from United States

Army practice, and purification of sink wastes, with the final sterilization by hypo-chlorite treatment, continued to be the governing principles. The designs for the various purification and sterilization works were developed by the writer's force under L. P. Wood, assistant designing engineer, subject to the approval of the sanitary expert as well as the department and the chief engineer.

Concluding, the writer wishes to emphasize that while proper specifications and methods of payment are of great assistance in enforcing proper sanitation, the coöperation of contractors, engineers and sanitary supervisors is absolutely essential to any considerable measure of success, and this coöperation has been notably present on the Board of Water Supply work, due in no small measure to the author of the paper, his associate, Dr. Pease, and to their predecessor, Dr. Ernst J. Lederle.

DISCUSSION OF PAPER, "A STUDY OF SAND FOR USE IN CEMENT MORTAR AND CONCRETE."

(VOLUME XLVIII, PAGE 189, APRIL, 1912.)

MR. FREDERIC I. WINSLOW. — In 1910, the writer was asked to undertake, through the Testing Department of the Sewer Division of the City of Boston, a number of experiments to test the value of the various commercial sands used in conjunction with cement in structures in and near Boston.

The cement used was all drawn from one bag of Lehigh Portland cement, of which, on sieve test, 7 per cent. remained on the No. 100, 12 per cent. on the No. 120, and 25 per cent. on the No. 200.

The annexed table shows the results:

The neat cement used tested as follows: One day, 280 lb.; one day in air and six days in water, 600 lb.; one month, 786 lb.; three months, 710 lb.; six months, 700 lb.; the mixture in the sand tests was uniformly one to three by weight, about 8 per cent. of water being added.

No. of Test.	Per Cent. of Sand Left on No. 20 Sieve.	Per Cent. of Sand Left on No. 30 Sieve.	Per Cent. of Sand Left on No. 40 Sieve.	Per Cent. of Sand Left on No. 50 Sieve.	Per Cent. of Sand Left on No. 100 Sieve.	Per Cent. of Sand Passed No. 100 Sieve.	Seven Day Test.	Twenty-eight Day Test.	Three Months Test.	Six Months Test.	Twelve Months Test.
1	17	8	12	13	29	20.5	138–144	244–205	355–387	342–355	....
2	35.5	44	19.5	1	0	0	180–198	238–250	286–295	318–335	....
3	25.5	17	18	21.5	15	2	128–140	210–218	247–252	242–264	245–245
4	50	24.5	11.5	7	6	1	137–145	185–231	224–235	240–252	....
5	9	9.5	18	31.5	26	5	138–154	210–215	234–246	270–275	....
6	13.5	22.5	26	23	11.5	2.5	155–162	212–225	297–310	300–305	....
7	2	14	32	35	17	0	130–132	208–217	250–266	240–248	....
8	0	2	18.5	59.5	19	1	135–139	208–226	258–265	260–272	....
9	2	10.5	29.5	44	14	0	170–174	232–244	255–262	261–273	....
10	37	11	11.5	13	16	11.5	177–182	270–280	318–338	365–368	....
11	31	11	14	16	19	9	80–87	126–130	187–195	200–208	....
12	17	16	21.5	23	16	6.5	155–160	210–215	296–314	328–335	....
13	0	0	2.5	71.5	25	1.5	140–150	188–200	280–288	260–265	....
14	6.5	4.5	9	15.5	37.5	26	75–90	186–190	234–240	340–380	220
15	1	3	15.5	30.5	39.5	9.5	105–107	225–230	324–336	252–258	....
16	29.5	16	20	11	15.5	7.5	158–170	245–260	330–314	368–380	392–390
17	23	21.5	32	13.5	8.5	1	210–218	287–295	360–370	340–335	370–375

Association of Engineering Societies.

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PROCEEDINGS.

Engineers' Club of St. Louis.

St. Louis, December 6, 1911. — The 711th meeting of the Engineers' Club of St. Louis was held at the Club rooms, 3817 Olive Street, on Wednesday, December 6, at 8.30 p.m., President Von Maur presiding.

There were present 31 members and one visitor. This was the annual meeting for the year 1911.

The minutes of 710th meeting of the Club were read and approved and the minutes of the 504th meeting of the Executive Committee were read.

The following gentlemen were elected to membership:

As Members — C. L. Holman, F. N. Jewett, W. S. Merkle, J. W. Himmelsbach, C. L. Orth, Edw. Gray, A. B. Johnson, J. H. Boughton, C. H. Specht.

As Associate Members — A. Neumayer, O. F. Huch.

As Junior — R. T. Toensfeldt.

The following were proposed for membership in the Club: K. H. Hansen, M. C. Andrews, H. C. Grote, J. M. Bischoff, J. D. Mortimer, B. F. Bush, W. P. Carmichael.

A letter from the Citizens National Committee with reference to arbitration treaties was read. The President was authorized to appoint a special committee to consider the proposed resolutions and to report on December 15.

The names of the members proposed by the Nominating Committee for election to the several offices of the Club were placed in nomination. No other nominations being offered, Mr. Greensfelder moved that the nominations be closed. Motion seconded and carried. Professor Langsdorf called attention to the fact that the Club was now entitled to a fourth member of the Board of Managers of the Association of Engineering Societies. Mr. S. W. Bowen was nominated as the fourth member, and his name was ordered placed on the ballot.

The following reports were received and accepted: Report of the Executive Committee, by Mr. Von Maur, chairman; report of the Secretary, by W. W. Horner; report of the Treasurer, by W. E. Rolfe; report of the Membership Committee, by J. W. Woermann; report of the Entertainment Committee, by E. D. Smith; report of the Meetings and Papers Committee, by

E. L. Ohle; report of the Joint Council, by E. L. Ohle; report of members of Board of Managers of the Association of Engineering Societies, by John Hunter.

The report of the Treasurer was referred to the Executive Committee with power to refer to certified accountant.

The report of the Meetings and Papers Committee was also referred to the Executive Committee.

Mr. Greensfelder presented the final report of the Committee on Quarters. This report showed that $70.15 had been spent for special work for the Club, $35.55 for the Academy of Science, and $1 235.54 under the agreement between the two societies.

Messrs. Rolfe and Langsdorf were appointed as a special committee to confer with the Academy of Science with reference to procuring a new lantern for the meeting room.

Professor Langsdorf reported for the Committee on the Patent Laws. The report follows:

Your Committee on Patent Law, authorized at the meeting of October 4, 1911, begs to report that it has held several meetings to consider the matter placed before it, and submits its findings in the form of the following resolution:

Whereas, there exists a widespread dissatisfaction with the system of legal procedure under which patent causes are adjudicated, which dissatisfaction frequently finds expression in a demand for the establishment by Congress of a special Patent Court or Patent Commission in the same way that such tribunals as the Interstate Commerce Commission, the Court of Commerce and the Court of Claims have been established; and

Whereas, a patent may be adjudged valid in one circuit and invalid in another circuit of concurrent jurisdiction, resulting in the anomalous condition that in the same circuit one party may be prohibited by one court from making, using or selling the patented device, while another party (not the owner of the patent) may make, use or sell a device exactly similar to that of the first party because another court has ruled the patent invalid as to him; and

Whereas, there is no limit to the time during which an applicant for a patent may continue to urge his views upon the Patent Office in an effort to have included claims which the Patent Office thinks should not be allowed, thereby giving an opportunity to the applicant to incorporate in his specification and claims ideas obtained from progress made in the art subsequent to the filing of the original application, and thereby also unduly deferring the beginning and ending of the life of the patent; and

Whereas, reissues with broadened claims may be granted after intervening rights have accrued to others, and without public notice that such reissue is contemplated, thus making it necessary for these others to go to the expense of litigation to protect themselves against the consequences of acts which, at the time such acts were performed, did not infringe the original patent; and

Whereas, a patent after having being duly issued may be placed in interference with a pending application, at the same time preventing the public from making, using or selling the device of the patent during the course of the interference proceedings; and in the event that the rights of invention are adjudged to lie in the application and to be vested in the owner of the application, a firm or individual, by controlling both the patent and the application, may secure virtual monopoly rights for a longer period than the seventeen years given by act of Congress as a reward for inventive genius;

Therefore be it resolved, that the Engineers' Club of St. Louis respectfully calls the attention of the President of the United States to the conditions herein outlined, and, further, that it respectfully requests that he incorporate in a message to Congress a recommendation that remedial legislation be enacted.

Resolved, further, that copies of these resolutions be sent to the members of the Cabinet and of Congress, and to the executive officers of other engineering and technical organizations with a request for action endorsing them.

The committee recommends, in conclusion, that a permanent committee be authorized and appointed to handle such future business as these resolutions may develop.

A. S. Langsdorf, *Chairman.*
J. H. Kinealy.
A. H. Timmerman.

This report was accepted and the Secretary was instructed to have the resolutions printed and distributed as recommended in the report.

Adjourned 9.20 P.M.

W. W. Horner, *Secretary.*

St. Louis, December 15, 1911. — The 712th meeting of the Engineers' Club was the annual dinner. This was held at the Mercantile Club on Friday, December 15, 1911, at 7.30 P.M.

There were present 80 members of the Club and associated societies.

The program consisted of speeches by Messrs. J. D. Von Maur, B. F. Bush, Hugh L. Cooper, C. M. Woodward, A. P. Greensfelder and Geo. J. Tansey.

Messrs. Bush and Cooper were unfortunately called away from the city at the last moment.

After the regular speeches, Messrs. Edw. Devoy and Maxime Reber were called on informally.

Mr. Reber expressed the thanks of the officials in charge for the work of the Club's Committee on the Municipal Bridge approach.

The following resolutions were unamiously adopted by the meeting:

"*Whereas*, the best interests, welfare and prosperity of the people of the United States are largely dependent upon a condition of peace at home and abroad; and

"*Whereas*, international treaties are now pending before the United States Senate which are calculated to bring about such a condition by providing for the settlement by arbitration of practically all differences which may arise between the governments that are parties to such treaties;

"*Therefore, be it resolved*, that we, the Engineers' Club of St. Louis, Missouri, in regular session assembled, hereby express our deep and active interest in the ratification of said treaties substantially as submitted and earnestly urge the senators for this state to use their efforts to obtain early and favorable action upon them by the Senate."

The result of the letter ballot for officers for 1912 and for honorary members was announced. The following were elected:

President — A. S. Langsdorf.
First Vice-President — John Hunter.
Second Vice-President — H. H. Humphrey.
Secretary — W. W. Horner.
Treasurer — W. E. Rolfe.
Librarian — E. O. Sweetser.
Directors — E. L. Ohle, Hans Toensfeldt.

Members of the Board of Managers of the Association of Engineering Societies — W. S. Henry, Baxter Brown, H. A. Wheeler, S. W. Bowen.

Honorary Members — M. L. Holman, Robert Moore.

W. W. Horner, *Secretary.*

ST. LOUIS, JANUARY 3, 1912. — The 713th meeting of the Engineers' Club was held at the Club rooms, 3817 Olive Street, on Wednesday, January 3, 1912, at 8.15 P.M. This was a joint meeting under the auspices of the American Society of Engineering Contractors, St. Louis Section. The total attendance was 68, of which 40 were members of the Club.

President Langsdorf of the Engineers' Club called the meeting to order. The reading of the minutes of both societies was suspended. The names of the following were proposed for membership in the Club.

Membership — J. A. Pearson, H. H. Horner, C. E. Brenton, G. S. Lang, W. S. Ashton, C. S. Johnson, J. L. Burlingame.

Associate Members — E. D. Bell, G. F. Cottrill.

Junior — A. W. Buckingham.

The following were elected to membership: Henry C. Grote, J. M. Bischoff, M. C. Andrews, W. P. Carmichael, B. F. Bush, James D. Mortimer, Karl H. Hansen.

President Langsdorf then turned the meeting over to Chairman W. P. Carmichael, of the St. Louis Section of the American Society of Engineering Contractors.

Messrs. M. C. Andrews and H. M. Cryder, Vice-Presidents of the Carmichael Company, presented a paper on the "Construction Features of the Kingshighway Viaduct." The paper was read by Mr. Andrews and the views were presented by Mr. Cryder. The paper caused considerable discussion along the lines of proportioning concrete and of finishing concrete surface for architectural effect. The discussion was led by Mr. Greensfelder; other speakers were Messrs. Schuyler, Homer, Childs, Talbert, Carmichael, Conzelman, McArdle, Henby, Murphy, Cryder and Andrews.

Adjourned 10.20 P.M.

W. W. HORNER, *Secretary*.

Boston Society of Civil Engineers.

BOSTON, MASS., DECEMBER 20, 1911. — A regular monthly meeting of the Boston Society of Civil Engineers was held this evening at Chipman Hall, Tremont Temple, at 7.40 o'clock, Vice-President James W. Rollins in the chair. The members of the American Society of Mechanical Engineers and of the Boston Section of the American Institute of Electrical Engineers joined in this meeting, the attendance being 220.

It was voted to dispense with the reading of the record of the last regular meeting and to approve the same as printed in the December *Bulletin*.

The President appointed Messrs. F. H. Fay, C. R. Gow and L. L. Street as tellers to canvass the letter-ballots on the endorsement of the report of the Committee of the Boston Chamber of Commerce on Fire Prevention. Later in the meeting the tellers reported that the whole number of ballots cast was 291, of which 273 were yes and 18 no. The chair declared that as more than two thirds had voted in favor of the endorsement it was adopted.

The Secretary reported for the Board of Government that it had elected the following to membership in the grades named:

Member — Roy L. Lamphear.

Juniors — William A. Bryant and Fred B. Skillin.

The Secretary reported the death of Lyman L. Gerry, a member of the Society, which occurred on July 15, 1911, and by vote the President was requested to appoint a committee to prepare a memoir. The President has appointed as this committee Mr. A. M. Lovis.

On motion of Mr. Higgins, the thanks of the Society were voted to Charles Logue Building Company and the Concrete and Expanded Metal Company for courtesies shown members on the occasion of the excursion to the new Ball Park, this afternoon.

At 8 o'clock Prof. W. L. Hooper, chairman of the Boston Section of the American Institute of Electrical Engineers, assumed the chair and introduced Mr. W. L. R. Emmett, engineer of the General Electric Company, who read a paper on " Electric Propulsion of Ships." The paper was illustrated by lantern slides. A general discussion followed the reading of the paper. Adjourned.

S. E. Tinkham, *Secretary*.

January Meeting of the Sanitary Section.

A special meeting of the Sanitary Section of the Boston Society of Civil Engineers was held Wednesday evening, January 3, 1912, at the Boston City Club. The dinner preceding the meeting was attended by 21 members and guests. Chairman George A. Carpenter presided over the meeting. There were 36 present.

Mr. Edward Hutchins, engineer with the International Paper Company, of Glens Falls, N. Y., gave an abstract of his paper on " The Disposal of Paper Mill Waste." Mr. Hutchins described briefly the process of making paper, and the character of the wastes resulting. Various kinds of " save alls " and other methods of purifying these wastes were illustrated by means of lantern slides. The paper dealt principally with the work which has been carried on at the plant of F. W. Bird & Son, of East Walpole, Mass., and described in detail the disposal plant developed. Mr. Hutchins advocated the passage of laws to establish standards to which the paper manufacturers could reasonably be required to purify their wastes. The question of to what extent should such wastes be allowed to enter municipal sewerage systems without preliminary treatment was also touched upon, as well as the problems to be encountered when large quantities of water in the form of wastes are diverted from a river used for power purposes.

The paper was discussed by Messrs. R. S. Weston, E. Worthington, George A. Carpenter, Charles W. Sherman and Edward Wright, Jr.

On motion of Mr. Edward Wright, Jr., and duly seconded, it was voted to extend the thanks of the Section to Mr. Hutchins for his kindness in preparing the paper presented.

The meeting adjourned at 10 o'clock p.m. Frank A. Marston, *Clerk*.

Civil Engineers' Society of St. Paul.

St. Paul, Minn., January 8, 1912. — The twenty-ninth annual meeting of the Civil Engineers' Society of St. Paul was called to order by President L. P. Wolff, at 6.30 p.m., in the Secretary's office of the St. Paul Commercial Club, Germania Life Building, St. Paul. There were present 28 members, 1 junior and 4 guests.

The minutes of the previous meeting were read and approved.

The applications of Theodore Simerman and Karl L. Hullsick, for full membership in the Society, were read, and upon motion, carried, the Secretary was directed to cast a ballot of the Society and elect the applicants as petitioned. They were declared elected. The resignation of Mr. H. J. Bernier as a member of the Society was read, and upon motion, carried, the Secretary was directed to write Mr. Bernier and express to him the regret of the Society at his action, and to request him to reconsider the same, with a view of remaining with the Society as a non-resident member. The resignation of Garrett O. House was read and upon motion, which prevailed, the same was accepted.

A set of resolutions adopted by the Engineers' Club of St. Louis, Mo , on December 6, 1911, concerning the necessity for "Remedial Patent Legislation," was then read, and upon motion, which prevailed, the Chair was to appoint a committee of three, whose duty it would be to analyse the resolutions and report at the next meeting, February 12, 1912. Messrs. A. F. Meyer, H. LeRoy Brink and John F. Druar were appointed as the committee.

The annual reports of the officers for the year 1911 were read, accepted and ordered filed. Election of officers for the year 1912 was then held, and resulted as follows:

D. F. Jurgensen, President; J. H. Armstrong, Vice-President; L. S. Pomeroy, Secretary; Oscar Palmer, Treasurer and Librarian; A. R. Starkey, representative on the Board of Managers for the Association of Engineering Societies.

The meeting then adjourned and the members retired to the banquet room of the Commercial Club, and enjoyed the feast which the committee had prepared, which was participated in by 36 members and 11 guests.

Ex-President Wolff acted as toastmaster, and spoke on "The Accomplishment of the Society during the Year Just Closed."

D. F. Jurgensen was called upon to respond in the way of remarks on "How It Felt to be Elected President."

Mr. R. B. Fanning, president of the Engineers' Club of Minneapolis, told how the Minneapolis Club did things.

L. W. Rundlett related some early reminiscences and experiences of the "Pioneer Engineer."

Mr. J. H. Armstrong spoke on the "Good Roads Development in the State," with special reference to the progress made by Ramsey County.

Mr. Charles A. Forbes explained in detail the proposed trip to the Panama Canal now being arranged by the Minnesota State Surveyors' and Engineers' Society, Engineers' Club of Minneapolis, and the Civil Engineers' Society of St. Paul.

Hon. Herbert P. Keller, mayor of St. Paul, spoke on "Importance of the Engineer in Developing the Country."

Mr. J. B. Gilman, of the Minneapolis Club, spoke on "The Structural Engineer."

Mr. Edward J. Dugan spoke on "The United States Engineers' Part in Controlling the Waters of the Mississippi."

Mr. Parker Simons gave an interesting talk on "The Hardships and Privations of the Pioneer Engineer."

Mr. Oscar Claussen spoke on "How it Feels to be City Engineer of the City of St. Paul."

The speakers engaged the attention and interest of those participating in the banquet until 11.45 P.M., when adjournment was taken by mutual consent.

D. F. JURGENSEN, *Secretary.*

② Association

of

Engineering Societies.

Vol. XLVIII. FEBRUARY, 1912. No. 2.

PROCEEDINGS.

Boston Society of Civil Engineers.

Boston, January 24, 1912. — A regular meeting of the Boston Society of Civil Engineers was held this evening at Chipman Hall, Tremont Temple, at eight o'clock, President Charles T. Main in the chair; 105 members and visitors present.

The record of the last meeting was read and approved.

The Secretary reported for the Board of Government that it had elected the following to membership in the grades named:

Members — Clarence Lester Foster, Stephen Perkins Hurd and Morse Wooley Rew.

Juniors — John Prescott Wentworth and Robert Emerson Parker.

Associate — Frank Willis Clark.

The Secretary announced the death of the following members: Edward Sawyer, who died December 27, 1911, and Samuel Clarence Ellis, who died January 22, 1912, and by vote the President was requested to appoint a committee to prepare memoirs. The President has appointed the following as members of these committees: On memoir of Edward Sawyer, Messrs. Fred. Brooks and C. F. Allen, and on memoir of S. Clarence Ellis, Messrs. Frank O. Whitney and F. M. Miner.

The Secretary read a letter from Mr. Allen Chamberlain, clerk of the Committee on Legislature of the Appalachian Mountain Club, calling attention to bill before the legislature relative to the sale of atlas sheets of the map of Massachusetts, and expressing the hope that the Society would take some action, looking to the amending of the bill so as to provide for the future sale of these sheets.

After an explanation by Past-President Howe, it was *voted:* That it is the sense of this meeting that House Bill No. 225 should not be passed in its present form and that it should be so amended as to provide for a continuation of the sale of these sheets at the State House.

Mr. Howe was authorized by vote to appear at any hearing which might be held in relation to this bill and represent the Society on the matter.

On motion of Mr. Edward W. Howe, the President was requested to

appoint a committee of three to report to the meeting the names of five members to serve at a committee to nominate officers for the ensuing year.

The President named as that committee Messrs. E. W. Howe, R. A. Hale and R. S. Weston. This committee reported later in the meeting the following names, and by vote of the Society, they were chosen as the Nominating Committee: Henry D. Woods, Bertram Brewer, Dwight Porter, John N. Ferguson and William E. Foss.

The Secretary presented a memoir of George C. Dunne, late an associate of the Society, prepared by a committee consisting of F. A. Barbour, B. R. Felton and F. W. Clark. The memoir was accepted and ordered to be printed in the JOURNAL.

Mr. W. H. Jaques brought to the attention of the Society the proposed meeting of the Permanent International Association of Navigation Congresses, which will be held in Philadelphia in May next. At the close of the congress the delegates will visit a number of the large cities of the country, and arrangements have been made for their entertainment. The Chamber of Commerce, the Boston City Club and the Institute of Technology have already expressed their willingness to do their part in entertaining the delegates, and he suggested that the Boston Society of Civil Engineers appoint a committee to represent it in the entertainment of the visitors. By vote the President was requested to appoint such a committee, to consist of three members. The President named as that committee Messrs. William H. Jaques, Ira N. Hollis and Frank W. Hodgdon.

Mr. Edward S. Larned then read the paper of the evening, entitled "A Study of Sand for Use in Cement Mortar and Concrete." Mr. Larned also read, through the courtesy of the author, Mr. Cloyd M. Chapman, engineer-in-charge, Westinghouse, Church, Kerr Company, New York City, his paper entitled "Waterproofing with Water," presented at the National Association of Cement Users at their seventh annual convention, December, 1910.

The papers were both illustrated by lantern slides. The papers were discussed by Messrs. Sanborn, Bryant, Adams, Larned and others.

Adjourned.

S. E. TINKHAM, *Secretary.*

FEBRUARY MEETING OF THE SANITARY SECTION.

BOSTON, MASS., FEBRUARY 7, 1912. — A special meeting of the Sanitary Section of the Boston Society of Civil Engineers was held this evening at the Boston City Club. Dinner was served at 6.15 to 39 members and friends.

The meeting was opened at 7.30 by Chairman George A. Carpenter. It was announced that John P. Wentworth had been enrolled as a junior member of the Section. The chairman also stated his intention of appointing a committee to consider nominations for officers and committees for the coming year and report same at the annual meeting in March. Although this was somewhat informal, and subject to objections from the members, the chairman considered it was for the best interests of the Section. No objections were offered.

The speaker of the evening was Mr. Ezra B. Whitman, at present chief engineer of the Baltimore Water Board, but formerly engineer in charge of the design and construction of the Baltimore Sewage Disposal Works. He gave a very interesting description of the development of this great sewage disposal project. The Walbrook Experiment Station was briefly described,

and tabulations were shown giving some of the results from the sprinkling filters and from the disinfection experiments. Plans and photographs were shown to illustrate the design and the construction methods employed on the Back River works. As this plant has been in operation but a short time, and, further, because there have been but few house connections made to the sewers and the sewage now being treated is largely ground water, it was impossible to give any operating results of value. Mr. Whitman used more than one hundred slides in illustrating his talk.

A number of gentlemen engaged in the discussion following the talk. A discussion on " Separate Sludge Digestion Tanks " was read by Mr. Charles Saville, and Mr. Frederic P. Stearns, one of the consulting engineers to the Baltimore Sewerage Commission, added further facts of interest. Mr. Harrison P. Eddy pointed out that the last few years had brought rapid advances in the science of sewage disposal, and that old opinions were being necessarily changed for new ones.

On motion of Mr. Eddy, seconded by Mr. R. S. Weston, it was voted to extend a vote of thanks to Mr. Whitman for his kindness in coming to Boston to give the talk, which had been of great interest and value to all present.

The meeting was adjourned at 10.40 o'clock.

That considerable interest was aroused is shown by the fact that the majority of the 65 members and guests present stayed until the meeting closed, although many were from out of town.

FRANK A. MARSTON, *Clerk*.

Montana Society of Engineers.

BUTTE, MONT., JANUARY 13, 1912. — The regular monthly meeting was called to order at the appointed hour, President Whyte in the chair. The minutes of the last meeting were approved as read. The application of John C. Beebe for membership was considered, approved and the usual ballot ordered. The resignation of Emil Starz was accepted, and Messrs. Borgnis, Blackford and Heller transferred to the corresponding membership class. On motion it was voted to suspend all members three years in arrears for dues prior to January 1, 1912. The chair named the following committee on nomination of officers of the Society for the ensuing year: Chas. W. Goodale, George E. Moulthrop, William J. McMahon. The Secretary reported the death during the past year of Charles W. Paine, Charles H. Palmer, Malcolm L. MacDonald. The President named Resolution Committees as follows: For Chas. W. Paine, Messrs. Carrol and Kyd; for Charles H. Palmer, Messrs. Goodale and E. H. Wilson; for Malcolm L. MacDonald, Messrs. McArthur and Hobart. A communication was read by the Secretary bearing on the question of the revision of the mining laws of the United States, and after considerable discussion it was voted to call a special meeting for February 3 for the further consideration of the matter, and a committee consisting of Messrs. Barker, Lindsay, Whyte and Dunshee were selected to lead in the discussion.

Mr. Charles W. Goodale gave a talk on his recent trip to Japan, illustrated by maps, pictures and curios. Many commendatory remarks were expressed, attended by a unanimous vote of thanks. Adjournment followed.

CLINTON H. MOORE, *Secretary*.

Technical Society of the Pacific Coast.

REGULAR meeting held at the residence of the Secretary, 1926 Broadway, December 15, 1911, at 8 o'clock P.M.

There were present a number of the old-time members who discussed the status of the Society and the possibility of making it again the useful organization that it once was.

The President, Mr. Dickie, spoke of the coming technical activity in connection with the Panama-Pacific International Exposition of 1915, for which the city of San Francisco has to make adequate preparations.

The Secretary called attention to the fact that there were so many local organizations in this city now, that are composed of the members of the great national societies, such as the American Societies of Civil, Mechanical, Electrical and Mining Engineers; not to mention the technological societies, such as the Chemical Society, the Mining and Metallurgical Society, the Society of Naval Architects and Marine Engineers, the Pacific Coast Gas Association the Society of Testing Materials, and many others, — all of them dealing with certain specialties in engineering, — that the main and original purpose of the Technical Society, namely, to bring all these heterogeneous branches of the profession under one Pacific Coast organization, has been eliminated to a great extent since the days of this specialization.

He thought, however, that its connection with the Association of Scientific Organizations may infuse a new interest into its membership, and that the coming meeting of the Association, to be held at the Stanford University in the early part of the coming April, should be thoroughly advertised, and its importance made known to every member, in order to induce him to write papers for discussion and publication.

It was agreed that the Secretary write circular letters to most of the individual members, requesting them to submit papers on engineering subjects for the coming occasion.

Mr. Manson, Mr. Wright, Mr. Schulze and Mr. Larkin discussed this important subject very earnestly, all of them expressing the hope that during the coming year an earnest effort be made to rehabilitate the status of the Technical Society.

It was in order to select a Nominating Committee of five members, who are to choose a ticket of officers to serve during the year 1912, and upon some discussion the following selection was made: Mr. Marsden Manson, chairman; Mr. Hermann Barth, Colonel W. H. Heuer, Professor Hermann Kower, Mr. Adolf Lietz.

Mr. Manson was instructed to call together his committee, and to submit to the Secretary a ticket within the next two weeks.

The Treasurer, Mr. E. T. Schild, stated that he had not been able to submit his financial statement, for obvious reasons, but that he would send it to the Secretary within a few days after the first of January, for publication and approval by the Board.

(He did so immediately after January 1, 1912, and the following statement is hereby attached to these minutes.)

1911.				
Jan. 10.	Balance in bank	$884.34		
	Cash on hand	8.00		
			$892.34	
	Cash receipts during 1911		646.00	
				$1 538.34

1912.					
Jan. 10.	Expended during 1911			$756.20	
	Balance in bank		$818.64		
	Less checks drawn, but not returned:				
	No. 159	$3.50			
	No. 160	39.00			
			42.50		
				776.14	
	Cash on hand			6.00	
					$1 538.34

CASH RECEIPTS.

Jan. 10.	Cash in bank	$884.34	
	Cash on hand	8.00	
	For dues	486.50	
	From two banquets	154.50	
	Admission (1)	5.00	
			$1 538.34

DISBURSEMENTS.

Jan. 10.	Salary of Secretary, November 20, 1910, to December 20, 1911			$195.00	
	Office work			40.50	
	Postage and expressage			37.26	
	Four assessments to Association of Engineering Societies			261.88	
	Two banquets			154.25	
	Mechanics Institute			5.50	
	Dues to Scientific Organization			5.00	
	Journals			3.36	
	Printing			53.45	
				$756.20	
	Balance in bank, January 1, 1912		$818.64		
	Less checks drawn after January 1, 1912:				
	No. 159	$3.50			
	No. 160	39.00			
			42.50		
				776.14	
	Cash on hand			6.00	
					$1 538.34

Respectfully submitted by

E. T. SCHILD, *Treasurer.*

The meeting adjourned, to be called by the President to transact the business of the annual meeting.

Attest,

OTTO VON GELDERN, *Secretary.*

Oregon Society of Engineers.

THE annual meeting of the Oregon Society of Engineers was held on Monday evening, February 5, 1912, at eight o'clock, at the Bowers Hotel, Portland, Ore., following the annual dinner, to which 93 sat down, including members and guests.

Vice-President O. B. Coldwell presided, in the absence of the President, and the minutes of the last Society meeting were read and approved. The address of the President was read by the presiding officer. Annual reports from the Secretary, the Treasurer, chairmen of committees on Membership, Library and Program, were read and approved.

Results of ballot for election of officers were then read by Mr. Russell Chase, spokesman for the tellers, as follows:

Vice-President — W. S. Turner.

Secretary — J. C. Stevens.

Treasurer — F. A. Naramore.

Directors — P. A. Schuchart, J. H. Morton, Fred Hesse.

Nominating Committee — T. M. Hurlburt, J. P. Newell, J. R. Thompson, J. A. Fouilhoux, R. H. Spencer, W. G. Hamilton, M. R. Colby, E. D. Searing.

Wm. R. King, E. G. Hopson, Orrin E. Stanley, Walter H. Graves and O. Laurgaard were appointed delegates to attend the Irrigation Congress to be held at the Commercial Club Rooms February 19-21.

The President was authorized to appoint a committee (the number of members to be left to his discretion) to consider amendments to the Constitution.

The formal business of the Society having been dispatched, the members listened to a very excellent paper read by Mr. W. H. Crawford, Pacific Coast representative of Chas. C. Moore Company, on the Steam Power Plant at Redondo, Cal. The remarkable efficiency and high test shown for this large steam generating plant will always remain a monument to the conscientious work of the contractors in the erection of the plant, and the large bonuses received (something over $300 000) for efficiencies in excess of those guaranteed speak very highly for the engineering ability of the contractors.

A vote of thanks was tendered to Mr. Crawford for his paper.

A vote of thanks was also tendered to Mr. Coldwell and the Portland Railway, Light and Power Company, through whose courtesy the Society has been permitted to use the assembly hall in the Electric Building for its general meetings; and also to the retiring Vice-President, Directors and Nominating Committee.

Then followed an informal "get-acquainted" program, in which each member present arose, stated his name and gave a brief outline of his business. The meeting adjourned informally, all present being delighted with the evening's program and expressing their desire, by a rising vote, that the dinners and get-acquainted meetings be held more frequently.

J. C. Stevens, *Secretary.*

ASSOCIATION

OF

ENGINEERING SOCIETIES.

VOL. XLVIII. **MARCH, 1912.** NO. 3.

PROCEEDINGS.

Engineers' Club of St. Louis.

ST. LOUIS, JANUARY 17, 1912. — The 714th meeting of the Engineers' Club was held at the Club rooms at 3817 Olive Street, on Wednesday evening, January 17, at 8.15 P.M., President Langsdorf presiding.

Present, 45 members and 31 visitors.

Minutes of the 711th, 712th and 713th meetings of the Club were read and approved.

Minutes of the 505th and 506th meetings of the Executive Committee were read.

The following gentlemen were elected to membership.

Members — J. L. Burlingame, G. S. Lang, C. E. Brenton, J. A. Pearson, H. H. Horner, W. S. Ashton, C. S. Johnson, W. F. Gradolph.

Associate Members — G. F. Cottrill, E. D. Bell.

Junior — A. W. Buckingham.

The following names were proposed: Members, V. A. Fynn, H. M. Cryder, F. J. Lasar, C. A. Waldo, W. A. Fuller. Junior, W. C. Harting, C. E. Gault.

A letter from the St. Louis Advertising Men's League was presented. The League requested the Club to pass resolutions endorsing a bill before the Municipal Assembly permitting and regulating the placing of electric signs on buildings. On motion, the matter was ordered laid on the table.

A letter from the St. Louis Society for the Relief and Prevention of Tuberculosis was presented. The Society asked the general coöperation of the Club by naming permanent delegates to work with them. On motion, the Secretary was instructed to express the Club's hearty interest and appreciation of the work of the Society, but the Club did not believe that they could be of any material aid in the matter.

A letter to the President from Mr. E. H. Abadie was read. Mr. Abadie notified the Club of the donation by Mr. Edw. Wegman, of New York, of a copy of Mr. Wegman's book entitled, "The Design and Construction of Dams." The Secretary was instructed to express to Mr. Wegman the appreciation of the Club for this addition to the library.

Dr. C. M. Woodward presented a " New Analysis of the Bent Beam." Dr. Woodward took the case of a beam fixed at one end and supported at the other, and evolved the equations for maximum moment, maximum deflection and for the points of occurrence of each, under a single moving load. He also deduced an equation closely approximating Euler's for columns, by considering the column to have been bent by uniform load at right angles to the axis.

At the conclusion of the paper, the members adjourned to the Library room, where refreshments were served.

Adjourned.

W. W. Horner, *Secretary.*

The 715th meeting of the Engineers' Club was held at the Club rooms at 3817 Olive Street on Wednesday evening, February 7, 1912, at 8.15 P.M.

The total attendance was 61, of which 32 were members of the Club.

This meeting was a joint meeting with the St. Louis Section of the American Society of Mechanical Engineers.

President Langsdorf called the meeting to order. The names of E. C. Davis and H. J. Steinbreder were proposed for membership. All other business of both sections being suspended, President Langsdorf resigned the chair to Chairman E. L. Ohle, of the St. Louis Section, A. S. M. E.

Mr. C. A. Hobein, superintendent of power stations for the United Railways Company, presented an illustrated paper, prepared by Messrs. C. A. Hobein and Chas. Young, on "A Comparison of Air Braking Systems for Urban Electric Railway Cars."

A general discussion of the subject followed.

Adjourned, 10.00 P.M.

W. W. Horner. *Secretary.*

Boston Society of Civil Engineers.

Boston, Mass., December 12, 1911. — A special meeting of the Boston Society of Civil Engineers was held at the Boston City Club this evening, and was called to order by the President, Charles T. Main, at 7.45 o'clock. There were 150 members and visitors present. Prof. Frank P. McKibben, of the Lehigh University, read a very interesting paper on " The Engineering Features of the Austin Dam," which was fully illustrated by lantern slides.

A general discussion followed the reading of the paper.

Adjourned.

S. E. Tinkham, *Secretary.*

Boston, Mass., February 21, 1912. — A regular meeting of the Boston Society of Civil Engineers was held this evening at Chipman Hall, Tremont Temple, at 7.50 o'clock, Vice-President James W. Rollins in the chair; 65 members and visitors present.

The record of the last meeting was approved as printed in the February *Bulletin.*

The Secretary reported for the Board of Government that it had elected the following to membership in the grades named:

Members — Henry Manley, Jr., and David S. Reynolds.

Junior — Thorndike Saville.

The Secretary presented the report of the committee (Mr. Andrew M. Lovis) appointed to prepare a memoir of our late associate, Lyman L. Gerry, and on motion the report was accepted and ordered printed in the JOURNAL.

On motion of Mr. Gow, the thanks of the Society were voted to The Concrete Engineering Company for courtesies extended to members of the Society who attended the excursion to the work now under construction by that company in East Boston.

The Secretary announced that the annual meeting would be held at the Boston City Club, on March 20, and that the dinner and other functions would be similar to those of the last two years.

Prof. Charles M. Allen was then introduced, and gave a very interesting talk on "Uses and Abuses of Gasoline and Kerosene." The talk was illustrated by a large number of experiments showing the dangers connected with the handling of these fluids.

Adjourned. S. E. TINKHAM, *Secretary.*

BOSTON, MASS., FEBRUARY 28, 1912. — A special meeting of the Boston Society was held this evening at the Boston City Club, at 7.30 o'clock, President Charles T. Main in the chair; 160 members and visitors present. An informal dinner preceded the meeting, at which 86 were present.

Baurat Wendemuth, the dock expert at Hamburg, who has been called to Boston to consult with the Directors of the Port, was the principal guest of the evening. He addressed the Society briefly, expressing his appreciation of the honor shown him in Boston, and was followed by Mr. Andreas G. Hartung, his assistant, who described the harbor improvements of Hamburg.

Messrs. F. W. Hodgdon, J. R. Freeman and O. F. Clapp of the Society, and Mr. William T. Donnelly of the American Society of Mechanical Engineers, spoke interestingly of harbor and dock work.

Adjourned.

S. E. TINKHAM, *Secretary.*

ANNUAL MEETING OF THE SANITARY SECTION.

BOSTON, MASS., MARCH 6, 1912. — The annual meeting of the Sanitary Section of the Boston Society of Civil Engineers was held this evening at the Boston City Club. Dinner was served at six o'clock to 26 members and friends. Following the dinner, the business meeting was opened at 7.30 o'clock with Chairman George A. Carpenter presiding.

The minutes of the previous meetings were declared approved as printed in the *Bulletins*.

The report of the Committee on "Rainfall and Run-Off from Sewered Areas" was read by H. P. Eddy, secretary of the committee.

On motion of C. W. Sherman and duly seconded, it was voted that the report be accepted and the committee continued.

On motion of H. P. Eddy and duly seconded, it was voted that the name of George C. Whipple be added to the membership of this committee.

Notice was given that Mr. Edgar S. Dorr had a number of interesting charts showing the intensity of rainfall observed over small areas. These were placed on exhibition after the meeting.

The report of the Committee on "The Collection and Tabulation of Sewerage Statistics" was read by H. P. Eddy, chairman of the committee.

On motion of W. S. Johnson, duly seconded, it was voted that the report be accepted, the recommendations be adopted and the committee discharged.

The report of the Committee on "Uniform Specifications for the Manufacture of Sewer Pipe" was read by Leonard Metcalf, chairman of the committee.

A motion was made by R. S. Weston, and seconded, that the report be accepted and the committee continued. It was so voted.

The report of the Executive Committee was read by the Clerk.

On motion of Leonard Metcalf, duly seconded, it was voted to accept this report.

Nominations were received for officers and committees to serve for the ensuing year as follows:

Chairman — George C. Whipple.

Vice-Chairman — X. Henry Goodnough.

Clerk — Frank A. Marston.

Additional members of the Executive Committee — Almon L. Fales, Lewis D. Thorpe, Erastus Worthington.

On motion of C. W. Sherman, duly seconded, it was voted that the polls be closed and that the chairman be authorized to cast one ballot for the officers and members of the Executive Committee as nominated.

As there was no further business to be transacted the meeting proceeded to the literary program.

The chairman introduced Mr. Leonard Metcalf, who gave an informal talk on "Some Sewage Disposal Plants in Germany, France and England," which he visited during the past fall. The talk was illustrated by a large collection of slides showing structural details of the more recent plants for the purification of sewage. Mr. Metcalf compared the work done by the Imhoff tanks with that done by the Travis tanks and various screening plants. The inodorous character of the sludge from the Imhoff tanks was also discussed. One of the most interesting and latest plants described was that for the city of Paris at Carrière-Triel. Among the German plants illustrated were the North Essen, Recklinghausen, Bochum, Stoppenberg, Cöpernick, Hagen, Wilmersdorf, Unna and Hamburg. The Parisian plant at Achères, and the English works at Birmingham, Yardley and Norwich were also shown.

Following the talk, Chairman George A. Carpenter made a few closing remarks and then introduced the new Chairman, George C. Whipple. The meeting adjourned at 9.30 o'clock. The attendance was 40.

Frank A. Marston, *Clerk.*

Civil Engineers' Society of St. Paul.

St. Paul, Minn., February 12, 1912. — The second regular meeting of the Civil Engineers' Society of St. Paul was held in the Society's quarters, Room 7, Old State Capitol, Monday evening, February 12. The meeting was called to order by President Jurgensen, with the following members and junior members present:

W. S. Batson, Wm. Danforth, D. B. Fegles, W. G. Hoyt, D. F. Jurgensen, W. E. King, A. F. Meyer, J. B. Mitchell, Oscar Palmer, L. S. Pomeroy, G. A. Ralph, Parker Simons, E. S. Spencer, H. A. Swenson, L. P. Wolff.

The minutes of the previous meeting were read and approved. Mr. D. B. Fegles reported for Entertainment Committee that State Engineer Geo. A. Ralph had kindly consented to deliver an address before the Society at this meeting, on "Water Power Resources in Minnesota." Mr. A. F. Meyer reported for the Special Committee appointed at the last meeting, at the solicitation of the Engineers' Club of St. Louis, to look into the subject of "Needed Remedial Legislation" concerning the United States Patent Laws, that said committee had not had sufficient opportunity to formulate a report with definite recommendations, and asked that this committee be allowed to continue its labors for another month. It was moved and carried that the committee be so authorized. It was moved and carried that a committee of one be appointed to interview certain of the members in regard to delinquent dues. The Secretary was authorized to communicate with Mr. C. L. Annan, notifying him that the President had appointed him as such committee.

Balloting for members then followed.

Mr. P. A. McLeod, assistant engineer, St. Louis & San Francisco Railway, was advanced to full membership. Mr. Geo. H. Herrold, office engineer, city of St. Paul, was elected to full membership.

The application of Mr. James A. Rowat, of Willmar, Minn., which it had been announced to the members of the Society would be balloted on at this meeting, was necessarily deferred until the next meeting, on account of the Examining Board's not having had sufficient opportunity to act on same.

The application of Mr. Edward O. Korsmo, engineer for the Toltz Engineering Company, was returned to Mr. Korsmo without action by the Society, in order that it might be made sufficiently specific to conform to the requirements prescribed by the Society's constitution.

An interesting address by Mr. Geo. A. Ralph, state drainage engineer, on the subject of "Water Power Resources in Minnesota" then followed, discussion of which by several members of the Society occupied the time till 10.30 o'clock, when adjournment was taken.

L. S. Pomeroy, *Secretary.*

St. Paul, Minn., March 11, 1912. — The Civil Engineers' Society of St. Paul assembled in the Society's rooms in the Old State Capitol, March 11, 1912, to listen to an address on "Patent Processes and Remedial Legislation concerning the United States Patent Laws," by John A. Stryker, a prominent patent attorney of St. Paul. A generous response from the students of the University of Minnesota, to whom an invitation had been sent to attend this meeting, made the use of the Hall of Representatives necessary.

The following members were present: J. N. Armstrong, L. G. Couter, W. L. Darling, Wm. Danforth, D. B. Fegles, Chas. A. Forbes, D. F. Jurgensen, A. F. Meyer, Oscar Palmer, L. S. Pomeroy, G. A. Ralph, Parker Simons, A. R. Starkey, H. A. Swenson, W. L. Van Ornum.

Mr. Stryker's address was especially clear and comprehensive, and the Society adjourned to its own quarters about 9.30 to attend its business meeting, feeling very much enlightened upon the vexed question of Remedial Patent Legislation, which it has been considering for the past two months.

After the reading and approving of the minutes of the last meeting, a motion was made and carried that the Society, or as many as could be gotten together, meet in special session, Monday, March 18, at 5.00 P.M., in the office of W. L. Van Ornum, in the City Hall, to pass upon the resolutions concerning Remedial Patent Legislation, submitted to it by the Engineers' Club of St. Louis at its January meeting.

The resignations of H. C. Palmer and Thos. M. Comfort, who have left the city to establish themselves in Regina, Saskatchewan, were read.

The Secretary was directed to write Messrs. Palmer and Comfort advising them that, by paying very materially reduced annual dues, they still could remain with the Society as non-residents, and asking them to reconsider their resignations.

A communication from the chairman of the National Drainage Congress Committee of the Louisiana Engineering Society, asking this Society to take under advisement the sending of delegates to said Congress, to be held in New Orleans April 10 to 13, was read.

The Secretary was directed to ascertain how many of the members of this Society would be willing to go as delegates at their own expense, and give the credentials of the Society to any such.

Balloting for members then followed.

The names of J. A. Rowat, with the Bridge Department of the Minnesota Highway Commission; Edgar A. Goetz, Chief Draughtsman for the St. Paul Foundry Company, and Alvin Haase, of Minneapolis, were proposed for membership. The Secretary was instructed to cast the ballot of the Society electing them to membership.

No further business coming before the Society at this time adjournment was taken at 10.15 P.M.

L. S. POMEROY, *Secretary.*

Montana Society of Engineers.

BUTTE, MONT., FEBRUARY 10, 1912. — The February meeting of the Society was called to order by President Whyte. Minutes of the January meeting were approved as read. The applications for membership in the Society of Messrs. Edward P. Mathewson and William Wraith were read, approved and the usual ballot ordered. Mr. John C. Beebe was elected to active membership. The Committee on Nomination of Officers for the coming year reported as follows: For President, Robert A. McArthur; for Vice-President, John H. Klepinger; second Vice-President, Reno H. Sales; Treasurer and member of the Board of Managers of the Association of Engineering Societies, Samuel Barker, Jr.; Secretary, Clinton H. Moore; Trustee for three years, George A. Packard. Report approved and Secretary instructed to send out the ballots. The Committees on Resolutions, relating to the deaths of Charles W. Paine and Malcolm L. Macdonald, reported thus, and were approved:

CHARLES W. PAINE.

In the death of Mr. Charles W. Paine, which occurred at his home in California, January 6, 1911, the Montana Society of Engineers has lost a valuable member, and those who knew him personally a valued friend and comrade.

Mr. Paine, during his residence in Montana, was an active and enthusiastic member of this Society. He was actively engaged in the construction of water works at Butte and Missoula, and later was employed by the government in his special line, hydraulics. For several years past he has lived on his place at Redlands, Cal., where he was universally loved and respected by his fellow townsmen.

As a friend, Mr. Paine was a man of even, kindly temperament, always the same, ever ready with kindly advice or assistance; a man whom all that knew him respected and felt proud to be associated with.

Professionally, Mr. Paine reached a high and prominent position in his chosen specialty, hydraulics. His advice and counsel were much sought in all parts of the country. A highly educated man, of sound judgment, large and varied experience, his loss to the profession and to the Society is great.

In extending our heartfelt sympathy to his bereaved family we realize that no words in this resolution can alleviate or lessen their grief, but we desire to add our tribute to the memory of a respected friend and honored member of our Society.

EUGENE CARROLL.
J. H. KYD.

MALCOLM L. MACDONALD.

Malcolm L. Macdonald was born at Mound House, Nev., 1865. He came to Montana in 1887 and entered the employ of Baker & Harper, civil and mining engineers, in the same year. Later he became a member of the firm of Harper & Macdonald, successors to the firm of Baker & Harper.

In 1904 he went to Tonopah, Nev., and established an office there and engaged principally in mining promotions, and was engaged in the same line of work at the time of his death, which occurred in New York City, October 22, 1911.

Your Committee recommend the following resolutions:

Whereas, the Montana Society of Engineers has suffered a loss in the death of Malcolm L. Macdonald, an old-time member of the Society, and one who during his residence amongst us took a leading part in the engineering activities of our state; and

Whereas, it seems fitting that we as a Society should record our respect and admiration for his character as a man and his ability as a member of the engineering profession, and deplore his sudden end; therefore, be it

Resolved, that we extend to his surviving relations our sincere sympathy in the loss they have sustained.

Resolved, that a copy of these resolutions be placed in the minutes of our Society and a copy be sent to the relatives of the deceased.

Respectfully,

R. A. MCARTHUR,
A. E. HOBART,
Committee.

On motion, Anaconda was selected as the place for holding the next annual meeting, and the Chair was instructed to select the necessary committees on program, etc. Then followed a discussion of the report of the Special Meeting Committee, at the close of which the committee was requested to revise their report by the insertion of the amendments approved.

Adjournment followed.

CLINTON H. MOORE, *Secretary.*

Technical Society of the Pacific Coast.

FEBRUARY 9, 1912. — A regular meeting of the Technical Society of the Pacific Coast was held in the Mechanics Institute Building, 57 Post Street, San Francisco, and called to order at 8.30 o'clock P.M. by President Dickie.

The minutes of the last regular meeting, held December 15, were read, including the report of the Treasurer, Mr. Schild, and upon motion they were approved as read.

The President appointed as tellers Mr. H. A. Schulze and Mr. Lawrence Thompson to open the ballots that have been received since the Nominating Committee rendered its report.

The tellers reported that thirty-four ballots were opened, and that the result of the count stood as follows:

For President — Loren E. Hunt, 34.

For Vice-President — G. Alexander Wright, 33.

For Vice-President — Henry A. Schulze, 1.

For Secretary — Otto von Geldern, 34.

For Treasurer — E. T. Schild, 34.

For Directors — F. C. Herrmann, 34; Hermann Kower, 33; Bruce Lloyd, 34; Hermann Meyer, 34; Henry A. Schulze, 34.

The President thereupon declared the ticket as proposed by the Nominating Committee elected, whereupon the newly elected President, Mr. Loren E. Hunt, took the chair.

The retiring President, Mr. Dickie, made a short address, appropriate to the occasion, stating that he was ever ready and willing to help in any way in his power the work of the Technical Society. He called attention to the coming convention of the Association of Scientific Societies, to be held at Stanford during the first week of the coming April, and advised that every effort be put forth to make this meeting a success.

Mr. Hunt followed, in well-chosen remarks, stating that nothing would be left undone, as far as lay in his power, to rehabilitate the activity and usefulness of the Society.

A general discussion followed, in which many of the members present took part. It was urged that papers be obtained for the coming meeting in April.

Mr. Schulze moved that a vote of thanks be extended to the retiring President, Mr. Dickie, for his constant efforts to labor for the benefit and usefulness of the Technical Society, and for his faithful services continued for so many years, during periods when the Society was most active as well as during more recent periods, after the great catastrophe, when it was a most difficult task to hold together the scattered remnants of what had been the first and best technical association on the Pacific Coast.

A vote of thanks was likewise extended to the Secretary for his past services; this was included in the motion, with the addition that the vote of thanks be spread upon the records.

The motion was carried unanimously.

The Secretary moved that when the meeting adjourn it be called again for the first Friday in March.

Attest,

OTTO VON GELDERN, *Secretary.*

REGULAR meeting held on Friday evening, March 8, 1912, at 8 o'clock, in the trustees' room of the Mechanics Institute, San Francisco.

The meeting was called to order at 8.15 o'clock by Past President George W. Dickie.

The minutes of the last meeting, of February 9, were read and approved.

The evening was devoted to a discussion of the coming meeting at the Leland Stanford, Jr., University, on April 6.

Two papers were announced as complete for that day; one by Mr. Harry Larkin: " The Development and Growth of the Asphalt Industries "; and one by Mr. J. H. G. Wolf, entitled, " Regulation of Industries by Governmental Supervision." Two other papers were promised, the titles of which have not been announced.

The chairman and the Secretary explained to the members what had been done in the matter of furthering an engineering congress in San Francisco in the Exposition year 1915. The component societies which constitute the organization working in the interest of an Engineering Congress were given by the Secretary, who also gave a list of names of the scientific societies who are making an effort to effect a local organization for the purpose of holding a great Scientific Congress during the Exposition year.

The meeting thereupon adjourned.

OTTO VON GELDERN, *Secretary.*

Association of Engineering Societies.

Vol. XLVIII. APRIL, 1912. No. 4.

PROCEEDINGS.

Engineers' Club of St. Louis.

St. Louis, February 21, 1912. — The 716th meeting of the Engineers' Club was held at the Club Rooms, at 3817 Olive Street, on Wednesday, February 21, at 8.30 p.m., President Langsdorf presiding. There were present 16 members and 19 visitors.

The minutes of the 714th and 715th meetings were read and approved, and the minutes of the 507th meeting of the Executive Committee were read.

The following gentlemen were admitted to membership:

Members — F. J. Lasar, V. A. Fynn, H. M. Cryder, C. A. Waldo, E. C. Davis, H. J. Steinbreder, W. A. Fuller.

Junior Members — C. E. Galt, W. C. Harting.

Following the recommendation of the Executive Committee, Mr. Schuyler moved that the Club employ a stenographer to report the proceedings of the meeting. Motion seconded and carried.

Mr. W. O. Pennell presented an illustrated paper on "Telephone Work." Mr. Pennell described the development of the modern telephone instruments and switchboards. He also described in detail the exchange building construction and arrangement and the transmission lines. The paper was illustrated with about one hundred lantern slides, and various portions of the apparatus were exhibited.

At 10.20 the meeting adjourned to the library room, where refreshments were served. W. W. Horner, *Secretary.*

St. Louis, March 6, 1912. — The 717th meeting of the Engineers' Club was held at the Club Rooms, at 3817 Olive Street, on Wednesday evening, March 6, at 8.30 p.m. The total attendance was about 105 (80 of whom were members and 25 visitors).

This was a joint meeting with the St. Louis Association of members of the American Society of Civil Engineers.

The meeting was called to order by President Langsdorf of the Club. The Secretary announced the name of Joseph Freund, proposed for associate membership.

President Langsdorf resigned the chair to Vice-Chairman M. L. Holman, of the St. Louis Association, A. S. C. E.

The program for the evening, consisting of a discussion of the "Use of Water Meters," was opened by Mr. Ed. E. Wall, who was followed by Messrs. Edw. Flad, S. Bert Russell, Hiram Phillips and J. R. Cullinane, all of whom presented written papers.

A general discussion of the subject followed.

Adjourned, 10.15 p.m. W. W. Horner, *Secretary.*

Boston Society of Civil Engineers.

Boston, Mass., March 20, 1912. — The annual meeting of the Boston Society of Civil Engineers was held at the Boston City Club, 9 Beacon Street, at 12.20 o'clock p.m., President Charles T. Main in the chair.

The record of the last meeting was read and approved.

The Secretary reported for the Board of Government that the following candidates had been elected to membership in the grades named:

Members — Lester H. Allen and Thomas W. Clark.

Junior — Carl C. Enebuske, Jr.

The Secretary read the annual report of the Board of Government and by vote it was accepted and placed on file.

The Treasurer read his annual report and by vote it was accepted and placed on file.

The Secretary read his annual report and by vote it was also accepted and placed on file.

Mr. R. K. Hale, for the Committee on Excursions, read the annual report of that committee, which was accepted and placed on file.

The Librarian read the annual report of the Committee on the Library and by vote it was accepted and the recommendations adopted by which the sum of $60 was appropriated for the purchase of current engineering books and the sum of $30 appropriated for a plan case.

On motion duly made and seconded, it was voted to refer to the Board of Government, with full powers, the question of appointing the special committees of the Society and the selection of the members thereof.

The tellers of election, appointed by the President, Messrs. H. E. Sawtell and M. T. Whiting, submitted their report giving the result of the letter ballot.

In accordance with this report the President announced that the following officers had been elected:

President — James W. Rollins.

Vice-President (for two years) — William S. Johnson.

Secretary — S. Everett Tinkham.

Treasurer — Charles W. Sherman.

Directors (for two years) — Charles M. Spofford and Robert Spurr Weston.

The President called upon Mr. FitzGerald, chairman of the committee appointed to select the best paper read before the Society and published for the year ending with the month of September, 1911. Mr. FitzGerald responded very graciously to the request and after briefly alluding to the pleasure it gave the donor of the medal to be the means of providing the Society with it, presented the first Desmond FitzGerald Medal in the name of the Society to Charles Rice Gow for his paper entitled, "Methods and Costs of Construction of the Slow Sand Purification Works for the new Springfield, Mass., Water Supply." Mr. Gow in accepting the medal thanked the Society not only for the medal but for the honor accorded him in selecting his paper for the prize.

At the request of the President, Mr. Bryant made a verbal report in regard to the Engineers Club of Boston. Mr. Bryant exhibited plans showing the arrangement of rooms in the Club House at the corner of Commonwealth Avenue and Arlington Street, and spoke particularly of the rooms which had been arranged for the library and meeting room for the Society.

The retiring President, Mr. Charles T. Main, then delivered an address entitled, " The Work, Aim and Conduct of the Engineer," which is printed in the March, 1912, JOURNAL OF THE ASSOCIATION OF ENGINEERING SOCIETIES.

On motion duly made and seconded, it was voted to request the Board of Government to appoint a committee of five to consider the question of a code of ethics for the Society, as suggested in the address of the President.

The members then adjourned to the auditorium of the City Club where members and guests to the number of 144 sat down to the Thirtieth Annual Dinner.

After the dinner, President Main introduced the President-elect, Mr. James W. Rollins, who thanked the members for the honor they had conferred upon him in his election to the presidency of the Society and assured the members that he would endeavor to discharge the duties of the office to the best of his ability.

Past-President John R. Freeman then gave a very interesting address illustrated by a large number of lantern slides describing a visit he had made to the City of Mexico for the purpose of examining the water supply of that city.

In the evening a " Smoker " was held in the auditorium of the City Club at which the attendance was over 300. The gathering was of the same informal character as those of former years, light refreshments being served and music furnished by an orchestra, and a vaudeville entertainment was added to the features of former years.

S. E. TINKHAM, *Secretary.*

ANNUAL REPORT OF THE BOARD OF GOVERNMENT FOR THE YEAR 1911–12.

BOSTON, MASS., March 20, 1912.

To the Members of the Boston Society of Civil Engineers:

In compliance with the requirements of the Constitution, the Board of Government submits its report for the year ending March 20, 1912.

At the last annual meeting the total membership of the Society was 797, of whom 746 were members of the Society, 9 juniors, 2 honorary members, 23 associates and 17 were members of the Sanitary Section only.

During the year the Society has lost a total of 43 members, 19 by resignation, 19 by forfeiture for non-payment of dues, and 5 have died.

There has been added to the Society during the year a total of 51 members of all grades; 47 have been elected and 4 reinstated.

The present membership of the Society consists of 2 honorary members, 742 members, 21 juniors, 24 associates and 17 members of the Sanitary Section only, making a total membership of 806, a net gain of 9.

The record of the deaths during the year is:

George C. Dunne, died May 23, 1911.
Lyman L. Gerry, died July 15, 1911.
Edward W. Hadcock, died October 10, 1911.
Edward Sawyer, died December 27, 1911.
S. Clarence Ellis, died January 22, 1912.

Ten regular and three special meetings have been held during the year. The average attendance at the regular meetings was 155 as against 138 last year, the largest being 350 and the smallest 35.

The following papers and talks have been given at the meetings:

March 15, 1911. — George F. Swain, W. S. Murray and Dugald C. Jackson, "The Electrification of the Steam Railroads in the Boston Metropolitan District." (Illustrated.)

April 5, 1911 (special students' meeting). — George B. Francis, "The Engineering Features of Pennsylvania Terminal Station in New York City." (Illustrated.)

April 19, 1911. — Edwin J. Beugler, "Some Byways in Turkey." (Illustrated.)

May 17, 1911. — Fred M. Kimball, "The Electric Motor in the World's Work." (Illustrated.)

September 20, 1911. — T. Howard Barnes, "Pile Protection," and an informal talk on "Guatemala and Her People from a Wayfarer's Point of View." (Illustrated.)

October 18, 1911. — Fred A. Wallace, "Power System of the Pacific Mills, Methods and Rules for, and Cost of Operation." (Illustrated.)

November 15, 1911. — Charles L. Norton, "Some Refractory Substitutes for Wood." (Illustrated.)

December 12, 1911 (special). — Frank P. McKibben, "The Engineering Features of the Austin Dam." (Illustrated.)

December 20, 1911. — W. L. R. Emmett, "Electric Propulsion of Ships." (Illustrated.)

January 24, 1912. — Edward S. Larned, "A Study of Sand for Use in Cement Mortar and Concrete." (Illustrated.)

February 21, 1912. — Charles M. Allen, "Uses and Abuses of Gasoline, Kerosene, Etc."

February 28, 1912 (special). — Discussion on Harbor and Dock Improvements by Bauret Wendemuth and others.

The Sanitary Section of the Society has had four meetings during the year, with an average attendance of 44.

The papers read at the meetings of the Section were:

March 1, 1911. — Frank A. Barbour, "The Hudson Sewage Disposal System and the Disastrous Effects of Wool Waste." (Illustrated.)

March 1, 1911. — Robert Spurr Weston, "The Disposal of Manufacturing Waste." (Illustrated.)

December 6, 1911. — Louis K. Rourke, "A Talk on the Panama Canal." (Illustrated.)

December 6, 1911. — Andrew J. Provost, Jr., "Sanitation of Construction Camps along the Catskill Aqueduct." (Illustrated.)

December 6, 1911. — William W. Locke, "Sanitation of the Contractor's Camps in the Wachusett Basin." (Illustrated.)

January 3, 1912. — Edward Hutchins, "The Disposal of Paper Mill Waste." (Illustrated.)

February 7, 1912. — Ezra B. Whitman, "The Baltimore Sewage Disposal Works." (Illustrated.)

The following paper presented to the Section by title was accepted and published in the JOURNAL for April, 1911:

"The Use of the Salinometer in Studies of Sewage Disposal by Dilution." By Kenneth Allen.

On April 5, 1911, a special meeting was held at the Boston City Club, at which the students in the civil engineering courses at Harvard, Tufts and the Institute of Technology were the guests of the Society, about 300 being present. Past President George B. Francis gave an illustrated talk on "The Engineering Features of the Pennsylvania Terminal Station in New York City," and a social hour followed, enlivened by college songs.

The regular June meeting this year took the form of a dinner at the Inn, Sterling, Mass., at the end of a delightful automobile trip to the various works of the Metropolitan Water Works. It has always been difficult to secure a fair attendance at an evening meeting held at the time of the long days in June, and the change made this year, holding the meeting during an outing, was most thoroughly enjoyed by those who were able to attend.

For the regular meetings held in October, November and December, a new departure was made this year, the members of the American Society of Mechanical Engineers and of the Boston Section of the American Institute of Electrical Engineers joining in these meetings, each society having charge of one meeting. This Society conducted the meeting in October, the Mechanical Engineers in November, and the Electrical Engineers in December. While this arrangement interfered slightly with the business of the Society conducted at a regular meeting, the plan has the advantage of combining engineering meetings in Boston and enabling our members to listen to valuable papers secured by the other societies.

The third dinner of the engineers of Boston, under the joint management of the American Society of Mechanical Engineers, the Boston Section of the Electrical Engineers and this Society, was held at the Hotel Somerset on January 15, 1912, the particular arrangement this year falling upon this Society. The attendance was 400, and it was as enjoyable an occasion as those of former years.

Through the generosity of our former president, Desmond FitzGerald, the Board has the pleasure of awarding a prize for the best paper published by the Society for the year ending with the month of September, 1911.

Under the rules governing the award of the Desmond FitzGerald Medal, adopted by the Society, a committee of three appointed by the Board has recommended, and the Board has adopted, the recommendation, that the medal this year be awarded for the paper entitled, " Methods and Costs of Construction of Slow Sand Purification Works for the new Springfield, Mass., Water Supply," by Charles R. Gow.

The Board desires to congratulate the Society upon the very beautiful and artistic design which the donor has secured for the medal, and to express its appreciation of the time and labor which Mr. FitzGerald has spent in its preparation.

After more than two years' work, the general committee appointed from the various societies and organizations have evolved a plan for an Engineers' Club, which promises to be a success.

The owner of the property at No. 2 Commonwealth Avenue has made a proposition to remodel the building so that it will be suitable for a club and a home for the Boston Society of Civil Engineers, and to lease it to the Club, with an option to be purchased in the future.

When this property became available, a sufficient number of men signed the necessary papers to obtain a charter, and the club was organized.

The Board of Governors hold weekly meetings to elect new members and to transact business, and on March 14 there have been elected 329 resident and 66 non-resident members, with no great endeavor to induce any one to join, and it is expected that the full membership of 500 resident and 200 non-resident members will soon be reached.

This Club will meet a long-felt need for better social relations between engineers and others engaged in or connected with scientific pursuits.

The present quarters of the Boston Society of Civil Engineers have been outgrown, and new and more commodious quarters must soon be obtained. The Society is now a tenant-at-will and can move by giving six months' notice.

Provisions are being made in the plans of the Engineers' Clubhouse for accommodating the Society, and it is hoped that the Society will find a more permanent home in this building.

The accommodations planned for the Society are to have an assembly hall capable of seating about two hundred, provision for the library and such small offices as may be required for the officers and Board of Government. A separate entrance will be made for the Society, and there will also be direct connection with the club quarters.

The club proper will contain all the usual appointments of a modern, first-class club, including dining rooms, sleeping rooms, billiard room, etc.

It is expected that the building will be ready for occupancy before the first of the next year.

Under the arrangement as planned by the club, no funds of the club or Boston Society are invested in the property, and the only chances taken are for the lease of the property and payment of rent and running expenses. The property can be purchased at any time during the lease, if it seems wise to do so by the club, or at the end of the lease, if it would appear to be better to acquire other quarters, this can be done.

It will be seen from a study of the Treasurer's report, that the Society is in a good financial condition. There was a shortage at the end of last year. The increase in dues has increased the current income by nearly $1 900. Great economy has been exercised by the various officials of the Society, and the deficit of last year has been wiped out, and the Society will begin the new year with about $700 available of the current funds. This improved condition could not have been brought about without an increase in the dues.

The permanent fund is well invested and has turned the $30 000 mark.

For the Board of Government,

Chas. T. Main, *President.*

Annual Report of the Secretary, 1911–12.

S. E. Tinkham, Secretary, *in account with the* Boston Society of Civil Engineers. *Dr.*

For cash received during the year ending March 20, 1912.

From entrance fees:

31 Members	at $10 =	$310.00	
4 Associates	at 10 =	40.00	
12 Juniors	at 5 =	60.00	
Total from entrance fees			$410.00
Total from annual dues			6 464.50
From sale of Journals			8.25
From advertisements			988.50
From rent			1 125.00
Total			$8 996.25

BOSTON, March 20, 1912.

We have examined the above report and found it correct.

L. LEE STREET,
CHAS. R. GOW,
Directors B. S. C. Engineers.

ANNUAL REPORT OF THE TREASURER, 1911–12.

To the Boston Society of Civil Engineers:

Your Treasurer presents his report for the year ending March 20, 1912.

The financial information is submitted in three tabular statements. Table 1 contains the profit and loss statement, together with the corresponding figures for the three preceding years, for comparison. Table 2 exhibits the balance sheets at the beginning and end of the year. Table 3 shows how the Permanent Fund is invested.

In examining Table 3, it must be remembered that the book value of the several bonds represents the market value of two years ago, except in the case of bonds bought since that time, which are entered at cost. The present market values, however, would differ from the figures given by less than one hundred dollars, on the aggregate. The par value of the bonds is $23 600, and they are carried on our books at $22 975.50. They could probably be sold to-day for about $22 900.

The value of the Permanent Fund is now about $30 000. The interest return has been at the rate of 4.4 per cent. on the average value of the fund for the past year.

With the increase in annual dues, the current income of the Society has been increased by nearly $1 900. By the exercise of great economy, the excess of income over expense has been made to exceed $1 200, indicating that without the increased dues there would have been a shortage of about $700 for the year in current funds. As it is, the shortage of last year has been wiped out, and the Society will start the new year with nearly $700 of current funds available.

Respectfully submitted,

CHARLES W. SHERMAN, *Treasurer.*

TABLE I. — PROFIT AND LOSS STATEMENTS.

Income:

	1908–09.	1909–10.	1910–11.	1911–12.
Members' Dues	$4 113.00	$4 332.00	$4 567.00	**$6 448.50**
Advertisements	1 090.00	850.00	1 004.50	**984.50**
Library Fines	4.24	3.50	4.75	**5.56**
JOURNALS sold	....	6.50	4.50	**8.25**
Interest	....	....	10.47	**22.81**
Total Current Income	$5 207.24	$5 192.00	$5 591.22	**$7 469.62**
Entrance Fees	$600.00	$670.00	$945.00	**$410.00**
Contributions	100.00	100.00	200.00	**100.00**
Interest on Permanent Fund,	636.72	659.07	1 231.78	**1 301.72**
Total Income Permanent Fund	$1 336.72	$1 429.07	$2 376.78	**$1 811.72**
Surplus Account	....	....	1.50	....
Balance, Deficit	....	334.18	940.26	....
	$6 543.96	$6 955.25	$8 909.76	**$9 281.34**

Expense:

	1908–09.	1909–10.	1910–11.	1911–12.
Association Eng. Societies	$1 329.50	$1 661.62	$1 912.62	**$2 010.00**
Rent (net)	950.00	950.00	856.74	**920.00**
Light	36.30	48.54	53.76	**49.68**
Printing, Postage, Stationery,	1 544.16	1 397.48	1 770.96	**1 356.99**
Salaries	550.00	750.00	1 007.00	**992.00**
Reporting	100.00	152.50	282.00	**68.00**
Stereopticon	165.00	135.00	180.00	**130.00**
Books	53.35	83.00	72.10	**40.53**
Binding	145.20	73.20	81.20	**169.30**
Periodicals	28.50	36.50	31.00	**47.00**
Incidentals and Repairs	71.19	41.83	79.45	**84.94**
Insurance	8.88	8.88	26.38	**26.38**
Telephone	....	....	59.82	**65.24**
Sanitary Section	60.00	60.00	45.00	**14.24**
Annual Meeting, Jt. Dinner	....	118.88	43.45	**220.82**
Depreciation on Furniture	33.50	8.75	31.50	**34.25**
Total Current Expense,	$5 075.58	$5 526.18	$6 532.98	**$6 229.37**
Permanent Fund	$1 336.72	$1 429.07	$2 376.78	**$1 811.72**
Balance	131.66	....	....	**1 240.25**
	$6 543.96	$6 955.25	$8 909.76	**$9 281.34**

NOTE FOR 1911–1912.

Received from the Secretary during the year, $6 464.50 for dues. Of this, $68 was paid in advance for 1912–13, and has been credited to accounts

payable, leaving $6 396.50 collected during the year for current dues; $52 was paid in advance last year, making the total income for current dues, $6 448.50, as tabulated.

For advertising, $988.50 was received from the Secretary, and $4 was paid to the Association of Engineering Societies.

For rent, the Secretary has collected $1 125, of which $270.83 represents accounts receivable at the beginning of the year, leaving $854.13 of current receipts. Adding $145.83 accounts receivable at end of year, makes $1 000 received or due from sub-tenants. Rent has been paid, $1 800 for the Society Rooms and $120 for Chipman Hall, a total of $1 920, making the net cost of rent $920 as tabulated.

Table 2. — Comparative Balance Sheets.

	March 15, 1911.	March 20, 1912.
Assets:		
Cash	$260.63	$1 033.27
Bonds	19 430.50	22 975.50
Coöperative Banks	7 447.38	6 667.83
Savings Banks	370.33	132.21
Accounts Receivable	270.83	145.83
Library	7 500.00	7 500.00
Furniture	598.50	600.00
Current Funds (Deficit)	552.75	....
	$36 430.92	$39 054.64
Liabilities:		
Permanent Fund	$28 219.42	$30 031.14
Current Funds	....	686.00
Surplus	8 098.50	8 100.00
Accounts Payable	113.00	237.50
	$36 430.92	$39 054.64

Table 3. — Investment of Permanent Fund, March 20, 1912.

Bonds:

4	$1 000 Boston El. Ry. $4\frac{1}{2}$ per cent. bonds, due 1937, principal registered, at $105\frac{1}{2}$, =	$4 220.00
3	$1 000 Am. Tel. & Tel. Co., 4 per cent. col. tr. bonds, due 1929, principal registered, at $91\frac{1}{4}$ =	2 737.50
1	$600 Republican Valley R.R. 6 per cent. bond, due 1919, at 103 =	618.00
3	$1 000 C., B. & Q. R.R. joint 4 per cent. registered bonds, due 1921, at $96\frac{1}{4}$ =	2 887.50
2	$1 000 Union El. Lt. & Pr. Co. 5 per cent. bonds, due 1932, principal registered, at $102\frac{1}{2}$ =	2 050.00
	Amount carried forward	$12 513.00

	Amount brought forward		$12 513.00
2	$1 000 Blackstone Valley Gas & Elec. Co. 5 per cent. bonds, due 1939, principal registered, at $99\frac{3}{4}$ =		1 995.00
2	$1 000 Dayton Gas & Elec. Co. 5 per cent. bonds, due 1930, principal registered, at 100 =		2 000.00
1	$1 000 Milford & Uxbridge St. Ry. Co. 5 per cent. bond, due 1918, principal registered, at $96\frac{1}{4}$ =		962.50
3	$1 000 Railway & Light Securities Co. 5 per cent. bonds, due 1939, principal registered, at 100 =		3 000.00
3	$1 000 Superior Water Lt. & Pr. Co. 4 per cent. bonds, due 1931, at $83\frac{1}{2}$ =		2 505.00
			$22 975.50

Savings Banks:

Boston Five Cents Savings Bank (including interest to October, 1911)		132.21

Co-operative Banks:

25 shares Merchants Co-operative Bank (including interest to March)	$1 807.06	
25 shares Workingmen's Co-operative Bank (including interest to March)	1 943.97	
25 shares Volunteer Co-operative Bank (including interest to January)	2 916.80	
		6 667.83
Cash in Old Colony Trust Company		255.60
Total Permanent Fund		$30 031.14

Report of the Auditing Committee.

Boston, Mass., March 18, 1912.

We hereby certify that we have this day examined the books and records of the Treasurer of the Boston Society of Civil Engineers for the year 1911–12; that all receipts are properly accounted for and that there are proper vouchers for all expenditures.

We have also examined the securities and investments of the Society's funds, have verified and compared same with the books and found them all accounted for and properly carried.

We have compared the financial statement of the Treasurer with the books and find it to be correct.

L. Lee Street,
Chas. R. Gow,
Directors.

Report of the Library Committee.

The forty-first annual report of the library and for the year 1911–12 is herewith submitted.

The number of books added to the library the past year has been 372, of which 123 were bound in cloth and 252 in paper. As usual most of the bound volumes consist of magazines, society publications and reports.

The library now contains 6 860 volumes bound in cloth. The total number in paper is not given, as many of these will be bound in cloth later, thereby diminishing the number in paper.

During the year 160 books have been loaned to members, and fines to the amount of $5.56 have been collected. So far as possible all fines are collected, but occasionally a refusal to pay is met.

Seventeen volumes on engineering subjects have been purchased at an expense of $40.53.

As recommended last year, the Clemens Herschel Library has been put into presentable shape by the purchase of more sections.

It was recommended last year that an outside room be hired for the storage of books not in demand. This has not been done, and, in view of the near promise of larger quarters, it may be postponed a year or two.

The committee realizes that the library is simply waiting for the time when a permanent and trained librarian can be afforded or as soon as the Society obtains a change of quarters. Until that time those using the library will be compelled to put up with the inconveniences due to cramped quarters and lack of trained officials.

The committee recommends that:

The sum of sixty dollars be appropriated for the purchase of current engineering books the coming year.

That thirty dollars be appropriated for the purchase of a second plan case as recommended last year.

Frederic I. Winslow,
Henry T. Stiff,
Edwin R. Olin,
James M. Siner,
G. V. White,
Committee on Library.

Report of the Committee on Excursions.

March 20, 1912.

To the Boston Society of Civil Engineers:

During the past year five xcursions have been made by the Society as follows:

	Attendance.
May 17, concrete buildings in Lawrence and Haverhill	60
June 21, automobile trip to Clinton	35
September 20, testing laboratory at the Watertown Arsenal	16
December 20, the Fenway Baseball Park	60
February 21, concrete buildings in East Boston	60

Total attendance, 231; average attendance, 46.

The committee has continued to collect data concerning "New Engineering Work," either in progress or contemplated, for publication in the *Monthly Bulletin* of the Society, and has contributed 28 pages to the nine *Bulletins*.

There is a balance in the hands of the committee of $52.94.

Respectfully submitted,

CHARLES R. GOW, *Chairman*.
RICHARD K. HALE, *Secretary*.

REPORT OF THE EXECUTIVE COMMITTEE OF THE SANITARY SECTION.

BOSTON, MASS., March 6, 1912.

In looking back over the past season's work in the Sanitary Section, it is to be noted that there has been at all times a live interest in the meetings, and that the quality ot the papers presented has been high. Your Executive Committee, in planning the meetings, has endeavored to cover a range from the general subject of popular interest to the special subject of interest to a smaller circle only; the idea being to make the Section of value not only to the specialist but also to the engineer in a broad field of work. At various times in the past, the hope has been expressed that the men in actual charge of sewerage systems and disposal plants would gradually be brought into the Section, and thereby be led to express their ideas and experiences. The amendments to the Constitution and By-Laws enacted during the past season limit the future membership of the Section to include only members of the Society. It is not anticipated, however, that this will act to any appreciable degree to the detriment of the Section because of the established fact that the laymen are not anxious to attend engineers' meetings.

During the past season, four meetings have been held with an attendance as follows:

	Attendance at Dinner.	Meeting.
March meeting	24	33
December meeting	34	43
January meeting	21	36
February meeting	39	65
Average	30	44

Your committee deemed it unwise to hold a June excursion, because the excursion planned by the Society was to be of a similar nature, and because of the feeling among many of the members of the Section that their business would not allow them to participate in two such occasions.

Owing to a change in plans of the speaker scheduled for the October meeting, it was necessary to cancel that meeting. The subject, however, was presented a few months later.

The following subjects have been discussed at the meetings:

March 1, 1911. "The Hudson Sewage Disposal System and the Disastrous Effects of Wool Waste," Frank A. Barbour. "The Disposal of Manufacturing Waste," Robert Spurr Weston.

(Both of the above papers were illustrated by lantern slides, and were subsequently published in the August, 1911, JOURNAL.)

December 6, 1911. "A Talk on the Panama Canal," Louis K. Rourke. "Sanitation of Construction Camps along the Catskill Aqueduct," Andrew J. Provost, Jr. "Sanitation of the Contractor's Camps in the Wachusett Basin," William W. Locke.

(The above papers were illustrated by lantern slides.)

January 3, 1912. "The Disposal of Paper-Mill Waste," Edward Hutchins. (Illustrated.)

February 7, 1912. "The Baltimore Sewage Disposal Works," Ezra B. Whitman. (Illustrated.)

The following paper, presented to the Section by title, was accepted and published in the JOURNAL for April, 1911: "The Use of the Salinometer in Studies of Sewage Disposal by Dilution," Kenneth Allen.

A paper entitled "The Emscher Sewerage District and the Imhoff Tank," Charles Saville, was published in the JOURNAL for July, 1911.

In considering the work of the Section, a study has been made of the records, and the following tabulation has been made to show the number of meetings held and the average attendance for each year since the Section was organized.

Season.	Number of Meetings Not Including Excursions.	Average Attendance for Season.
1911–1912	4	44
1910–1911	5	46
1909–1910	4	49
1908–1909	6	45
1907–1908	4	44
1906–1907	6	39
1905–1906	6	57
1904–1905	5	62
Previous	1*	120

* There were also two meetings for organization.

From this record it would appear that the Section has been well worth the effort expended, and the attendance has been well maintained.

The total membership of the Section is now 145, of which 17 are members of the Section only. Out of the total membership, 73 live outside of Boston and vicinity, and a large proportion of these live outside of New England.

There are three special committees of the Section as follows:

On Rainfall and Run-off: George A. Carpenter, chairman; H. K. Barrows, Lewis M. Hastings, Hector J. Hughes, William S. Johnson, Arthur T. Safford, Harrison P. Eddy, secretary.

On Collection and Tabulation of Sewerage Statistics: Harrison P. Eddy, chairman; Bertram Brewer, Charles Saville.

On Uniform Specifications for Sewer Pipe: Leonard Metcalf, chairman; E. S. Dorr, Charles R. Felton, Lewis D. Thorpe, F. A. Barbour, secretary.

The membership of the Section has been increased by 11 during the past season.

The financial relations between the Section and the Society have been changed, so that now all bills not covered by the per capita charge collected at the dinners are paid by the Treasurer of the Society after having been duly approved. No funds are carried by the Section. This is a marked improvement for all concerned, and will doubtless be the saving of both time and money.

The work of the committee would be greatly facilitated if the members of the Section would submit suggestions as to possible subjects for discussion or as to the names of gentlemen who might be induced to prepare papers.

Your committee has endeavored to arrange for a meeting at which the subject of "The Relation of State Boards of Health to Problems of Water and Sewage Purification" might be discussed by representatives from various states, but as yet it has not been possible to make any definite plans. It was also planned to have a discussion on "The Screening of Sewage" at this annual meeting, but it became necessary to make other arrangements. The committee feels that both of these subjects are of importance, and the hope is expressed that they may be discussed in the coming year.

Respectfully submitted for the Executive Committee,

GEO. A. CARPENTER,
H. K. BARROWS,
EDWARD WRIGHT, Jr.,
FRANK A. MARSTON,
Clerk.

REPORT OF THE COMMITTEE ON RAINFALL AND RUN-OFF.

BOSTON, MASS., March 6, 1912.

TO THE MEMBERS OF THE SANITARY SECTION OF THE BOSTON SOCIETY OF CIVIL ENGINEERS:

Gentlemen, — The Committee on Rainfall and Run-Off has held several meetings during the year, at which the data in its possession have been reviewed and discussed. It has become convinced that this data must be studied carefully in order to determine how much and in what form it is best to publish the same, but during the year that has passed the members of the committee have not had time to give to this data the necessary study and cannot yet present it to the Section in the best form for publication.

It is believed that it will be possible for the committee to put it into shape and publish it during the coming year, and it is, therefore, recommended that the committee be continued.

Respectfully submitted,

GEO. A. CARPENTER, *Chairman.*

REPORT OF COMMITTEE ON MANUFACTURE OF SEWER PIPE.

BOSTON, MASS., March 6, 1912.

TO THE MEMBERS OF THE SANITARY SECTION OF THE BOSTON SOCIETY OF CIVIL ENGINEERS:

Gentlemen, — The Committee on Uniform Specifications for the Manufacture of Sewer Pipe, which was continued with a view to the possibility of its coöperating with a similar committee appointed by the American Society for Testing Materials, reports that as the work of the latter association has not yet reached fruition, effective work by your committee has not been possible.

The local situation and attitude of the manufacturers of sewer pipe remain unchanged.

Your committee will be glad to be discharged, or, if it should seem wiser to the Section to continue it for the purpose of possible coöperation with the association referred to above (should the work of the latter attain fruition this year) it will hold itself in readiness for such work. The present committee is still of the opinion that it is undesirable for our association to attempt to prepare standard specifications which will be likely to be of service only in a very limited territory, and which might make coöperation with other associations at a later day more difficult.

Respectfully submitted,

LEONARD METCALF.
FRANK A. BARBOUR.
E. S. DORR.
CHAS. R. FELTON.
LEWIS D. THORPE.

COMMITTEE ON SEWERAGE STATISTICS.

MARCH 6, 1912.

SANITARY SECTION, BOSTON SOCIETY OF CIVIL ENGINEERS, BOSTON, MASS.

Gentlemen, — The Committee on the Collection and Tabulation of Sewerage Statistics makes report that it has been inadvisable to attempt to collect sewerage statistics during the past year. This work was done with such thoroughness as was possible, during the year 1909, and the results of that work were published in the JOURNAL OF THE ASSOCIATION OF ENGINEERING SOCIETIES, and are available for reference. The work required of city officials who furnish this information from year to year appears to add somewhat of a burden to their duties, and the committee has not felt that it was justified in asking to have this work done during the past year.

The form of statistics adopted by the Section has been adopted by several city officials and embodied in their annual reports. The committee feels that this forms a valuable part of the reports, and that its use should be encouraged. To this end your committee recommends that the printed blanks in its possession be turned over to the secretary of the Section, and that he be requested to make reasonable effort to have city officials interested in this line of work adopt this form and embody it in their annual reports.

The committee is of the opinion that it is unnecessary for the present to continue the collecting and compiling of sewerage statistics, as was done for one or two years, and suggests that the committee be now discontinued.

Respectfully submitted,

HARRISON P. EDDY, *Chairman.*

Civil Engineers' Society of St. Paul.

ST. PAUL, MINN., MARCH 18, 1912. — Supplementary to the regular meeting of the Civil Engineers' Society of St. Paul, held March 11, 1912, a special meeting was held at the office of member W. L. Van Ornum, in the City Hall, at 5 P.M., March 18, 1912, with the following members present:

C. L. Annan, D. B. Fegles, G. H. Herrold, A. F. Meyer, Oscar Palmer, L. S. Pomeroy, W. L. Van Ornum.

In the absence of both President and Vice-President, on motion of Mr. Palmer, Mr. C. L. Annan was elected chairman.

The Secretary stated in a few words the purpose for which this meeting was held, after which the resolutions drafted by the special committee, composed of Messrs. Meyer, Brink and Druar, appointed at the January meeting to inquire into the subject of needed remedial legislation, concerning the United States patent laws, reported through its chairman, Mr. A. F. Meyer, as follows:

Resolutions Relating to Remedial Patent Legislation

Whereas, our present laws governing the granting of letters patent and the adjudication of patent causes, do not secure to either inventor or public the greatest possible benefit to be desired from new and useful inventions,

Be it resolved, that the Civil Engineers' Society of St. Paul, Minn., respectfully urge upon the President and Congress of the United States the enactment of legislation to the following ends:

1. The establishment of a court of appeals in patent cases.
2. The limitation of the privilege of selling patented articles or processes with certain reservations and restrictions imposed upon the full enjoyment, use or resale thereof.
3. The designation of a fixed period of time, dated from the issuance of letters patent, at the expiration of which, should the owner have failed to use the right granted him by said letters patent, the government shall after due notification of the owner, license the use of said right in the interests of the original inventor and the public.
4. The appointment of a commission, representing the various interests involved, to investigate the laws relating to the granting of patent rights and the methods of legal procedure in patent causes, and to recommend such additional legislation as is deemed desirable.

Adolph F. Meyer,
H. Leroy Brink,
Committee.

By unanimous vote of those present, the resolutions were passed. The Secretary was directed to forward a copy of the resolutions to each of Minnesota's United States Senators, Representative F. C. Stevens, and the secretary of the Engineers' Club of St. Louis, Mo., at whose instance the inquiry into the subject of the United States patent laws had been brought about.

The object for which the meeting was called having been accomplished, the meeting adjourned.

L. S. Pomeroy, *Secretary.*

Montana Society of Engineers.

Butte, Montana, March 9, 1912. — President F. W. C. Whyte called the meeting to order. Robert A. McArthur acted as Secretary *pro tem.* Minutes of last meeting were read and approved. The applications for membership in the Society of Messrs. Anderson, Blake, Căpron, Cortright, Dam, Hayden, Jones, Tanner and Sheridan were read, approved and ballots ordered. Moved and carried that Mr. E. A. Cralle, of Anaconda, Mont., a charter member of

this Society, be reinstated and all past dues and assessments remitted. Messrs. Mathewson and Wraith were elected to active membership by a unanimous vote.

The following resolutions on the death of Mr. Charles H. Palmer were read by the Secretary and adopted:

CHARLES H. PALMER

Whereas, our esteemed member, Mr. Charles H. Palmer, has been taken away by death;

Resolved, that the members of the Montana Society of Engineers, in regular meeting assembled, express their great sorrow, and also their appreciation of Captain Palmer's high character as a man and an engineer;

Resolved, that these resolutions be spread upon the minutes of the Society, and a copy thereof be sent to the family of the deceased.

E. H. WILSON.
C. W. GOODALE.

The chairman of the Committee of the Special Meeting reported that the report had been revised and the amendments inserted, and said report would be sent to Mr. H. V. Winchell. The Secretary announced the death of Mr. John Herron, a charter member and ex-president of this Society, and President Whyte appointed John Gillie and C. W. Goodale as a committee on resolutions. The Chair announced the following Committee on Program for Annual Meeting: Messrs. Mathewson, Garred, Brillhart, Lemmon and Whyte. The President and Secretary were instructed to procure a special souvenir for the twenty-fifth annual meeting. President Whyte read a communication from A. W. Mahon, state engineer, relative to water measurements in this state, and action thereon was deferred for discussion and action till the annual meeting.

Adjourned.

ROBT. A. MCARTHUR, *Secretary pro tem.*

ASSOCIATION

OF

ENGINEERING SOCIETIES.

VOL. XLVIII. **MAY, 1912.** NO. 5.

PROCEEDINGS.

Civil Engineers' Society of St. Paul.

ST. PAUL, MINN., APRIL 8, 1912. — The regular April meeting of the Civil Engineers' Society of St. Paul was held, according to custom, on Monday evening, April 8, 1912, in the Society's rooms, D. F. Jurgensen presiding. The following members — H. L. R. Brink, Wm. Danforth, J. F. Druar, G. H. Herrold, D. F. Jurgensen, Alvin Haase, Oscar Palmer, L. S. Pomeroy, W. L. Van Ornum, also one visitor — were present.

The minutes of the March meeting, also of the special meeting held March 18, 1912, were read and adopted by the Society.

At the suggestion of the President, it was voted to have the minutes of the special meeting, together with the resolutions concerning needed remedial legislation concerning the United States patent laws, adopted at that meeting, published in the Association JOURNAL. The Secretary was directed to write the Association Secretary to this effect.

The Librarian reported a considerable addition to the library, in that all periodicals, up to the end of the year 1911, which it had been thought desirable to have bound, had been so bound, and new bookcases acquired by the Society to accommodate same.

No report from the Entertainment Committee being forthcoming, it was suggested that the Society inspect the plant of the Twin City Brick Company, at the invitation of member George W. Rathjens, superintendent of this plant, at some time in the near future. The Secretary was authorized to communicate with the chairman of said Entertainment Committee, offering this as a suggestion for their information.

The application of Edward O. Korsmo for membership, which had been held over from the February meeting, was acted upon at this meeting. The Secretary was authorized to cast the ballot of the Society for Mr. Korsmo, electing him to membership.

The business meeting having been thus concluded, the remainder of the evening was occupied with the reading and discussion of a paper on "Railroad Wrecks," by President Jurgensen. This was a very interesting paper and kept the time well occupied until 10.30 P.M., when adjournment was taken.

L. S. POMEROY, *Secretary.*

St. Paul, Minn., May 13, 1912. — The regular May meeting of the Civil Engineers' Society of St. Paul was held, according to custom, on Monday evening, May 13, 1912. The following members, together with eight visitors, were present:

W. S. Batson, L. G. Couter, Wm. Danforth, D. F. Jurgensen, Alvin Haase, G. H. Herrold, W. G. Hoyt, H. A. Lyon, A. F. Meyer, O. Palmer, L. S. Pomeroy, G. A. Ralph, G. W. Rathjens, S. B. Soule, E. S. Spencer, L. P. Wolff.

As had been announced, it was deemed advisable to defer the business meeting until after the lecture which was to be given, and after a very brief address by President Jurgensen, Mr. C. Herschel Koyl, an expert water analyst, of New York City, took the floor and gave a very instructive and entertaining discourse on "The Art of Water Purification." Mr. Koyl illustrated, by the use of samples of St. Paul city water, and other samples brought from North Dakota, how it was possible by the use of proper combinations of lime and soda compounds to eliminate by precipitation substantially all the impurities of these waters, leaving them clear as crystal. The Society was entertained in this manner until 9.45 P.M., when Mr. Koyl concluded his discourse, and Mr. George A. Ralph took the floor, to make a brief report to the society of the proceedings of the National Drainage Congress, held at New Orleans, La., April 10 to 13, 1912, to which Mr. Ralph was the society's delegate. Mr. Ralph closed his address with an exhortation to all who possibly could to make an especial effort to attend the next session of the Drainage Congress, at Charleston, S. C.

The business meeting followed Mr. Ralph's address. After the reading and approval of the minutes of the last meeting, Messrs. Palmer and Lyon made some suggestions with regard to the society's adopting a button. A motion was made that a committee be appointed to ascertain what the cost would be for such buttons, per dozen or per fifty. Messrs. Palmer and Lyon were appointed as such committee. A plan was presented for consideration by the society, by Mr. W. G. Hoyt, for enlarging the society's room by cutting a doorway through its west wall, thereby giving access to two more rooms which could be used jointly by the society and the Water Resources branch of the United States Geological Survey, of which Mr. Hoyt is the St. Paul representative. Messrs. Herrold, Hoyt, Lyon, Spencer and Ralph were appointed a special committee to act with the Executive Council of the society to look into the feasibility of this project.

The names of Messrs. P. E. Stevens, St. Paul city bridge designer; A. H. Schuett, manager for the Trussed Concrete Steel Company, St. Paul; W. H. Hoyt, assistant chief engineer of the Duluth, Missabe & Northern Railway, Duluth; W. A. Clark, chief engineer of the Duluth & Iron Range Railroad, Duluth; and R. L. MacKnight, of the F. J. Romer Construction Company, St. Paul, were proposed for membership. The Secretary was instructed to cast the ballot of the society, electing them to membership.

No further business coming before the society at this time, adjournment until October 14, 1912, was then taken.

L. S. Pomeroy, *Secretary.*

Montana Society of Engineers.

Twenty-Fifth Annual Meeting, held at Anaconda, Mont., April 11, 12, 13, 1912.

Thursday. — Preceding days gave promise of a splendid "Silver Anniversary." Enthusiasm was manifest by the evidence of an expected and promised large attendance. For some, the days were too long and the nights too short to await in "pious patience" the coming event. The constitutional amendment in the interest of the timid and the tender seemed productive of large profits, big results. Hotel keepers shook off their drowsiness and proclaimed the coming of another deluge of patrons. Eloquential banqueteers reviewed their engineering note-books and sought for jokes to add to the charm of their personalities. A gracious committee greeted the arriving members with courtly welcome and, at midnight, "silence, calm and still, rested on the lone plain and mighty hill." Those whom distance, disposition and difficulties kept away were to miss the sight of a royal company. One was there whose "curling" fame had risen like incense in the air, under another flag and frosty skies; another had shed his shoes in Banzai land, and still another and another had witnessed the scene of the Frenchman's failure, the American's success, and others had remained at home, consoling themselves with the assurance that the traveled ones would share with them engineering knowledge, portrayed in word pictures not made with ink on paper.

Friday. — The sun rose as peacefully as ever; his worshipers greeted his presence with their usual rites of outward ablutions and inward libations. Greetings were exchanged with the new arrivals whose reputations permitted them to come to town by night, thirst and appetite were abated, waiters waited for sapphire and gold kings to share with them their easy money, and at the appointed hour transit was made to the Washoe Smelter; there guards and guardians took charge of the party. The first thing started was an attempt by the Indians to join the St. Paul Symphony Choir, whose battle flag appeared on the trail to the works. With difficulty feelings were suppressed and inspection began. Many things were shown and said. The examination was exhaustive, but worth a more strenuous effort. The courteous Gaston and the gallant Alphonse vied with each other in accusing the other with being guilty of this and that method for robbing Dame Nature of her mineral wealth. A new mine caisson, a product of the brain of an ingenious engineer, had many admirers, and it is safe to say that if the concern is not a thing of beauty, it must be a joy forever. It is very popular in the mines of Butte. Joy rides took the visitants to new concentration works and method. A visit to the foundry afforded profit; a procession through the streets and lanes of the thriving Smelter City brought to a close a morning fair and debonair. After two hours of food and mental digestion, pleasures were enhanced by a short ride over the finest roads in Montana, and a stop was made at a ranch doing business in the Smoky Zone. The manager and his colleagues extended a cordial greeting. The many new methods of raising pork and beans were suggested, flocks and herds recited their recessionals, chickens sought their highest roosts, and the air began to thicken. A ditch-digging device attracted the engineers' surprise and approval. Auto horns sung in sweet harmony, and rapidly rolling wheels bore their drivers and loads toward the hills and fast flying sleet. Some decided to visit the Brick Plant; others, "that another little drink won't do us any harm." All hurried to witness the wreckage

of a mountain side by a monstrous blast. The witnessing permitted the enjoyment of the heat of a comfortable fire, the way the laborers, employed at the quarry near at hand, are kept on the pay-roll, and a view of the many oft-witnessed scenes. The key is pressed, the electric spark ignites, awful destruction follows, and over the highway leading down, the State Fish Hatchery was reached just in season to witness the hatching. Everybody knows that fish are hatched once a day, but is ignorant of the hour. Feeding time follows hatching time, and the residents of a near side pond presented an attractive spectacle while at dinner. Some boarders were taken on shore and introduced to their visitors, and the beautiful colors of their dress suits were greatly admired, while it was a quandary how the bright colors could be so preserved in the wet season. Happy words were exchanged with new arrivals at the evening hour. The hospitality of the Anaconda Club knew no bounds. Everybody vied with each other in bringing the profits and pleasures of the second day's experiences of the "Silver Anniversary" to a delightful end.

Saturday. — The business session of the Silver Anniversary was called to order in the spacious parlor of the Montana Hotel at 11 A.M., President F. W. C. Whyte in the chair. The minutes of the March meeting were read and approved. The applications for membership in the Society of Messrs. W. E. F. Bradley, Earl Dwight Covell, Albert K. Burrage, Thomas Good, Albert Edward Wiggin, Edward W. Kramer, Frank R. Ingalsbe, John Scott Harrison, 4th, and Robert Morris Johnson were presented, approved and ballots ordered. Messrs. Anderson, Blake, Capron, Cartright, Dow, Hayden, Jones, Sheridan and Tanner were elected to membership, with no opposing votes. Tellers Wheeler and Curtis were appointed to count the ballots for the officers for the year 1912, and they reported the election as follows: President, Robt. A. McArthur; First Vice-President, John H. Klepinger; Second Vice-President, Reno H. Sales; Secretary and Librarian, Clinton H. Moore; Treasurer and Member of the Board of Managers of the Association of Engineering Societies, Samuel Barker, Jr.; Trustee for Three Years, George A. Packard. President Whyte declared the election of the persons named and introduced the new president, who, after making some pleasing remarks, assumed the duties of his office. A vote of thanks was given the retiring officers for their diligence in securing new members. The annual reports of the Secretary and the Treasurer were read, adopted and ordered filed. The report of the Good Roads Committee was read, approved and the committee continued another year. The Secretary read the following report of the Resolutions Committee on the death of John Herron, and after the reading and adoption of the report, several members spoke in high terms of the noble character of the deceased, ex-President and Charter Member of the Society.

John Herron — A Memoir.

BY F. L. SIZER, JOHN GILLIE AND C. W. GOODALE, COMMITTEE OF THE MONTANA SOCIETY OF ENGINEERS.

(Read April 13, 1912.)

John Herron, a well-known mining engineer, died Saturday, February 3, 1912, as the result of an accident in the Pandora Mine, at Telluride, Colo., of which property he was in charge at the time of his death. Mr. Herron was fifty-four years old, having been born in India, December 31, 1857. He was educated at the University of Chicago, graduating with the class of 1880. He immediately took up railroad engineering, being first employed by J. F. Wallace on construction work in Illinois, and later, while still only twenty-

five years old, he became chief engineer of a new road in Ohio. For many years he followed railroad engineering and bridge construction in the Middle West, but reached Montana in the early days of the construction of the Great Northern, where he was known as one of the most competent locating engineers. In 1893, owing to the total suspension of railroad construction in the Northwest, he accepted a position with the Montana Mining Company, at Marysville, Mont., as a draftsman, and remained with that company for five years, working up to the position of superintendent, in direct charge of all its mine operations. In 1898 Mr. Herron went to the Tomboy Mine as general manager, and the English company operating that property, even after he was forced, as a result of a nervous breakdown, to give up active charge of the mine in 1904, consulted him frequently. From 1906 until last July he has been engaged in consulting work and made numerous trips to Mexico for the purpose of examinations.

John Herron's sterling qualities, as well as his marked ability as an operating man, were known to those who were closely associated with him, but he was of a most retiring disposition, and could hardly be induced to speak of his own work. His absolute honesty would not permit him to claim quite all the credit even which really belonged to him. It is greatly to be regretted that the profession has lost one whose standards were so high and whose personal character was so admirable.

He was a member of the American Society of Civil Engineers, of the Institution of Mining and Metallurgy of Great Britain, and charter member of the Montana Society of Engineers. In 1896 he was president of our Society, and always took a great interest in its affairs and progress.

Mr. Herron's home has been at Palo Alto, Cal., for the past eight years, and he leaves a widow and a son and two daughters.

Therefore, be it resolved, that we hereby express our sincere sympathy to his bereaved family, and that a copy of this memoir be spread upon the minutes of the Society.

Then followed the report of the Committee on Souvenir, and final action was deferred till after the banquet. On motion the Secretary was instructed to extend an invitation to the American Society of Civil Engineers to stop in Butte on their way to Seattle next June. Adopted. On motion the President and Trustees were instructed to find a suitable room for headquarters in Butte. A discussion regarding a silver button badge for the Society followed, and it was voted that the Committee on Button be continued and report further to the Society. A recess was taken till 2 P.M. President McArthur called the meeting to order and stated that the Secretary had some matters on his desk, which were then considered, to wit: The speech of Hon. Oscar W. Underwood, at the meeting of an Automobile Association, at Washington, D. C., January 16, 1912; remarks of Mr. John C. Beebe, on the Water Resources of the State and the necessity of accurate stream measurements and gaging; a communication from the state engineer, presented by Ex-President Whyte, asking for data on water gaging in the state. On motion a committee of three was appointed to reply to the request of the state engineer, and later the chair named as that committee Messrs. Gerry, Cochrane and Craven. Mr. Mathewson, president of the Good Roads Congress, requested that a committee from this association be appointed by the chair to attend the Congress and take part in the proceedings. On motion, his request was granted and two extra names were added to the existing Good Roads Committee, so that the committee for the occasion is composed of Messrs. Wheeler, Goodale, F. M. Smith, Blake and Moore. Under the eighth order of business was presented the annual address of the retiring President, Mr. F. W. C. Whyte; a paper on the Hebgen Dam, by H. H. Cochrane, and a thesis on Good Roads by Robert D. Kneale. These papers brought forth much favorable comment and added much in the

way of information to the records of the Society. Mr. Mathewson gave an explanation how Deer Lodge County secured such good roads, and the methods of their construction. The Secretary read letters from J. J. Donovan and W. A. Haven, telling of the early struggles of the Society, and congratulating its present membership on its loyalty to the organization. Mr. M. H. Gerry, Jr., told of his observations on the Canal Zone last winter, with special reference to the work in progress and the whiskey system of sanitation. The literary exercises were completed by the reading, by the Secretary, of a paper on Irrigation Projects in Montana, written by Mr. H. N. Savage, of the Reclamation Service, which paper came too late to be included in President Whyte's annual address. The thanks of the Society were voted to all contributors to the success of the Silver Anniversary of the Society, and Mr. Carroll's motion to adjourn was adopted. The usual banquet followed.

CLINTON H. MOORE, *Secretary.*

Technical Society of the Pacific Coast.

The May meeting of the Society was made the occasion for expressing to the past President, Mr. George W. Dickie, the Society's appreciation for his past services and his ever-ready counsel.

Mr. Dickie, having accepted a professional call to Philadelphia, will be absent from California for some time, — several years, possibly, — and, to meet him in public once more before his departure, a farewell dinner was given in his honor at the Bellevue Hotel on Saturday evening, May 11.

Forty guests assembled at the table to take part in the evening's entertainment.

After the dinner, Mr. Loren E. Hunt called the assemblage to order, and the Society proceeded with the order of the program.

Mr. Hermann Schussler responded to a toast, and related some very interesting experiences of his professional career, which were much appreciated.

Mr. Hermann Barth, a past director of the Society, entertained the guests by the provision of a fine musical program arranged for the evening, in which Mr. and Mrs. Barth, the Messrs. Schmidt and Mr. Adolph Herbst took part.

Mr. Marsden Manson spoke of Mr. Dickie as a man, and related some stirring incidents occurring at the trying time of the great San Francisco catastrophe in 1906, when both Mr. Dickie and he were in Philadelphia and far from their endangered homes and their kin and relatives.

Mr. Thomas Morrin spoke of Mr. Dickie as the manager of the great shipbuilding industry in San Francisco, and told the guests how faithfully and perseveringly Mr. Dickie had always labored for the benefit of the community.

Mr. H. A. Schulze spoke of the relation of the architect to the mechanical engineer, and referred to Mr. Dickie's activity in building construction.

Mr. C. E. Grunsky responded to a toast, and spoke of the work Mr. Dickie had performed in creating the battleship to protect the country's coasts, referring to the Panama Canal as the great gateway to connect the Occident with the Orient, which will create again the era of shipping, for the consummation of which Mr. Dickie has always labored faithfully.

Letters were read from Professor Marx and W. R. Eckart, congratulating the guest of honor.

The Secretary was then called upon to respond to the toast, "Scotland," the native land of Mr. Dickie, which he did in the following words:

"For years past it has been customary to make me the secretary of anything and everything that came along. It seems perfectly natural that I should be the secretary, and I take to the functions of this office as readily as a duck does to water.

"That is one reason why I do not apprehend any difficulty in the hereafter. I am certain to be there, too, the secretary of somebody or of something, — it may be of an incineration plant, — and by reason of my office I am sure to meet with the usual courtesies and privileges.

"However, that is neither here nor there. I am always glad to be of service, and particularly so if I am able to help in any worthy or good cause.

"Now, if there ever was a time when I was ready to take upon myself the secretarial functions, it is to-night, when it means to do honor to our good old friend,

"George W. Dickie.

"If ever there was a man ready to help his fellowmen, it was he. Those of us who have known him for over a quarter of a century know his worth, and we appreciate him. Therefore we honor him to-night.

"We are sorry to see him leave the country to which he belongs, — California, — but we are certain that he will return, and when he does so we shall not permit him to run off again in this way. He shall have to give an account of himself.

"What Mr. Dickie has been to engineering and to the iron industry of California, others have told you, and others will tell you to-night who are better able to dwell upon this than I am. It falls upon me this evening to refer to the country that gave us one of her best sons; to a beautiful country, full of romance and beautiful poetic tradition, —

"Scotland!

"Now, what I do not know about Scotland would fill an immense volume, and I shall for this reason call on some one else, as soon as I am through with my remarks, to accentuate and to represent Caledonia better than I am able to do this. You will find that this collaborator of mine is genuine, that he has all the attributes of the burr and the thistle.

"My knowledge of the land of the Scot has been derived from her authors. There was a time in my life, when a lad, that I used to sleep with Sir Walter, and when the real and the genuine poetry of Robert Burns, the like of which has not been, would stir me as no other has since. Walter Scott's 'Heart of Midlothian,' I remember, made such an impression upon my fancy that I have not forgotten it to this day.

"As I say, the Caledonia that I am acquainted with is based upon her writers.

"I know their pabulum well: from the almost indigestible meals of the grim Thomas Carlyle to the dainty dishes of Ian Maclaren and the beautiful romantic stories of William Black.

"I am sure that a Scot has every reason to feel proud of his country; he loves it so well that he even adheres strictly to certain portions of a Highlander's diet. I remember that Mr. Dickie inveigled me once, in his inimitable way, to eat a certain flapjack, or oatmeal pancake, and I have never forgiven him for that. As much as I love Scotland, I wouldn't try another one. I can eat pumpernickel with impunity (and my friend Dickie wouldn't touch that for love or money), but it does take a Highlander's stomach to digest the Caledonian pancake which he so highly recommended to me.

"The Highlanders, like the Germans, have many customs peculiarly their own. For instance, I, for one, have never been able to reconcile the kilt and the sturdy bare legs of the Caledonian with the peculiar emblem of their country, the thistle. If I were clad in a garb like that I would avoid any locality where thistles grew as I would avoid fishhooks. It appears more

rational to walk about in armor plate. I certainly would have to cultivate a love for this sharp-pointed national emblem before I got to like it.

"Scotland has given our country many of her best sons. The iron industry of to-day is due to the foresight, the ability and the sagacity of the iron men of that great country. These stern men of the Dickie type, they love to manipulate gigantic forces, to make that yield which opposes them most. Iron and steel is typical of their character. As strong as iron and as true as steel.

"But, while true to their adopted country, they never lose the love for their romantic Highlands, and from the Orkney Island to Gretna Green, and from the Firth of Lorne to the Firth of Forth they speak of it; in the language of their great poet:

"'Breathes there the man, with soul so dead,
Who never to himself hath said,
This is my own, my native land!'

"I told you that I had not the ability to paint Caledonia as it should be brought before you, and I have, therefore, sent for a delegate directly from the Highlands to make plain to you what I mean.

"*LONG LIVE MR. DICKIE!*"

A native Highlander here appeared in full costume, playing the pipes. He walked around the table, halted at Mr. Dickie's chair and played "Hail to the Chief!"

After singing "Auld lang Syne" the meeting adjourned.

OTTO VON GELDERN, *Secretary.*

Detroit Engineering Society.

REPORT FOR THE YEAR ENDING APRIL 19, 1912.

Membership.

Elected to membership and qualified during the year		171
Resignations	19	
Suspended for non-payment of dues	8	
Deaths	3	
		30
Net membership growth		141
Present membership (active)		351
Non-resident membership		44
Honorary members		2
		397

MEETINGS OF THE YEAR 1911–12.

May 19, 1911 (regular meeting). — Speaker, B. J. Denman, member of the society; "Description of Delray Stations No. 1 and No. 2 — Detroit Edison Company, Delray."

May 20, 1911. — Visit to plant of Detroit Edison Company, Delray.

July 15, 1911. — Annual excursion.

September 22, 1911 (regular meeting). — Speaker, J. C. Mock, member of the society. Subject, "Construction and Equipment of the New Detroit River Tunnel."

September 23, 1911. — Trip through Detroit River Tunnel.

October 20, 1911 (regular meeting). — Speaker, Irvin S. Osborn, of Columbus, Ohio, on "Garbage Disposal" and "Municipal Wastes."

November 3, 1911. — Smoker — New Members' Night.

November 17, 1911 (regular meeting). — J. W. Ellms, superintendent of Filtration Plant, Cincinnati, Ohio, speaker, on "Pure Water and Its Relation to Health."

December 1, 1911 (semi-monthly meeting). — Speaker, Abram T. Baldwin, member of society; subject, "The Importance of the High Test of CO_2 in Boiler Flue Gases and the Automatic Analysis and Record as Obtained by the Simmance-Abady Recorder."

December 15, 1911 (regular meeting). — Speaker, Clarence T. Johnston, member of the society; subject, "Egyptian Irrigation."

January 5, 1912 (semi-monthly meeting). — Speaker, Willis H. Carrier, of Buffalo, on "Air Conditioning Apparatus, Its Construction and Application."

January 19, 1912 (regular meeting). — Speaker, Evan J. Edwards, of National Electric Lamp Association, on "Latest Incandescent Lamps."

February 3, 1912. — Ladies' Night Party.

February 16, 1912 (regular meeting). — Speaker, F. C. McMath, member of society, on "Construction of the Lethbridge Viaduct on the Canadian Pacific Railroad."

March 1, 1912 (semi-monthly meeting). — Speaker, L. S. Smith, of General Electric Company, on "Small Motors."

March 15, 1912 (regular meeting). — Speaker, Davis Molitor, member of the society, on "Panama Canal."

April 5, 1912 (semi-monthly meeting). — Speaker, Maximilian Toch, of New York, on "Chemical Engineering, Old and New."

There were ten meetings of the Executive Committee during the year; also various meetings of special and standing committees.

Frederick H. Mason, *Secretary-Treasurer.*

Louisiana Engineering Society.

New Orleans, La., January 13, 1912. — The annual meeting of the Society was called to order with President Haugh in the chair.

The minutes of the meeting held December 11, 1911, were read and approved, and the minutes of the Board of Direction meeting held on the same date were read for the information of the members.

The annual report of the Treasurer was read and approved.

The annual report of the Secretary was read and approved.

Messrs. Coleman and Lawes were appointed as a committee to open the ballots for the new officers. These gentlemen reported the following results: There were 58 ballots cast, 2 of which were informal.

D. S. Anderson, President, 56 votes; A. M. Lockett, Vice-President, 55 votes; James M. Robert, Secretary, 56 votes; Ole K. Olsen, Treasurer, 56 votes; L. C. Datz, Member on Board of Direction for three years, 56 votes.

At this juncture, President Anderson was escorted to the chair by the retiring President, Mr. Haugh.

The annual report of the Board of Direction was read and approved.

There being no further business, the meeting adjourned to Galatoire's, where Chairman Shaw, of the Banquet Committee, had prepared an enjoyable spread for the Society and its guests.

James M. Robert, *Secretary.*

New Orleans, La., April 8, 1912. — The regular monthly meeting was called to order at 8.25 p.m., with President Anderson in the chair and 35 members and guests present.

The minutes of the meeting of March 11 were read and approved.

The President next called attention to the circular sent to the members urging coöperation in the matter of securing technical papers for the Society.

The technical exercises of the evening were next in order, and Professor Gregory was introduced. He read an interesting paper based on original investigation. The paper was entitled, "Seepage Losses from an Irrigation Canal."

The paper was rounded out with some excellent discussion by Messrs. Shaw, Coleman, Okey, Dusenbury and others.

Mr. Coleman next reported that his committee had had two meetings with the committee from the State Board of Engineering Examiners and that they had agreed upon certain changes in the law for the practice of civil engineering to be recommended to the next session of the state legislature. The proposed changes were read and are attached to these minutes.

Mr. Coleman moved, seconded by Mr. Garsaud, that it be the sense of this meeting that the proposed changes be adopted by the legislature. The motion was carried.

There being no further business, the meeting adjourned to partake of the usual collation.

James M. Robert, *Secretary.*

Association of Engineering Societies.

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PROCEEDINGS.

Engineers' Club of St. Louis.

St. Louis, March 20, 1912. — The 718th meeting of the Engineers' Club of St. Louis was held at the Club Rooms, at 3817 Olive Street, on Wednesday evening, March 20, 1912, at 8.30 p. m., President Langsdorf presiding.

There were present approximately 50 members and 30 visitors.

Minutes of the 716th and 717th meetings were read and approved and the minutes of the 509th and 510th meetings of the Executive Committee were read.

Mr. Jos. Freund was elected an associate member, and the application of H. B. Goodfellow for associate membership was presented.

Mr. E. D. Smith was elected to fill the vacancy on the Board of Managers of the Association of Engineering Societies, caused by the death of Mr. W. S. Henry.

A memoir of Mr. Henry, prepared by Mr. John B. Meyers, was read and ordered published in the Journal of the Association.

On the recommendation of the Executive Committee, the Librarian was instructed to report to the Club within one month a scheme for printing a new catalogue of the library in loose-leaf form, and for keeping same up to date.

The Secretary read a letter from the President in regard to the proposed organization of an Engineering Corps in the National Guard of Missouri. No action was taken in the matter. A letter from Mr. Warren B. Reed in regard to the National Drainage Congress at New Orleans was also read.

Mr. R. H. Nicholson, construction engineer for the Union Electric Light and Power Company, presented an illustrated paper on the construction of the East River wall of the Ashley Street plant and the circulating water intake.

The meeting adjourned, at 10.45, to the Library room, where refreshments were served.

W. W. Horner, *Secretary.*

St. Louis, April 3, 1912. — The 719th meeting of the Engineers' Club was held at the Club Rooms, at 3817 Olive Street, on Wednesday, April 3, at 8.15 p.m. This was a joint meeting with the St. Louis Section, A. I. E. E. The total attendance was 65.

President Langsdorf called the meeting to order. The Secretary read a letter from the Hon. F. W. Kreismann, in regard to the Central China Famine Relief Committee; also a letter from the Civic League in regard to a new charter for St. Louis. It was voted that the Engineers' Club go on record as favoring a revision of the city charter and that the President be authorized to appoint two delegates to a charter revision committee whenever it started to be organized.

The names of H. E. Wiedeman and T. A. Robinson were proposed for membership.

President Langsdorf resigned the chair to Chairman Lamke of the Local Section, A. I. E. E., who presided during the reading and discussion of a paper (illustrated) by A. H. Timmerman, chief engineer of the Wagner Electric Company, on "Unity Power Factor Motors."

Adjourned 10.00 P.M.

W. W. HORNER, *Secretary.*

ST. LOUIS, APRIL 17, 1912. — The 720th meeting of the Engineers' Club was a smoker, held at Cafferatas Restaurant, Hamilton and Delmar avenues, on Wednesday, April 17, in honor of Col. John A. Ockerson, president of the American Society of Civil Engineers.

There were about 95 members present. President Lansdorf acted as toastmaster, and formal speeches were made by Messrs. E. E. Wall, C. M. Talbert, Edward Flad and others. Colonel Ockerson responded, and informal talks followed.

Colonel Ockerson was presented with a large stein inscribed in commemoration of the occasion.

Adjourned 11 P.M.

W. W. HORNER, *Secretary.*

ST. LOUIS, MAY 1, 1912. — The 721st meeting of the Engineers' Club was held at the Club Rooms, 3817 Olive Street, on Wednesday evening, May 1, 1912. Present, 42 member and 34 visitors.

This was a joint meeting with the St. Louis Section of the American Society of Engineering Contractors.

President Langsdorf called the meeting to order. The names of H. F. Merker, E. W. Gallenkamp, Jr., and H. J. Elson were proposed for membership.

Messrs. H. E. Wiedeman and T. A. Robinson were elected members, and H. B. Goodfellow, associate member.

Mr. Humphrey moved that a committee of three be appointed to draw up resolutions of respect to the memory of Mr. William Bouton, who died on April 30.

President Langsdorf resigned the chair to Chairman Carmichael of the A. S. E. C., who presided during the remainder of the session.

Mr. A. J. Widmer, engineer for the Trussed Concrete Steel Company, presented an illustrated paper on "The Development of Long-Span Reinforced Concrete Floor Construction as applied to the Railway Exchange Building."

A general discussion followed.

Adjourned 10.10 P.M.

W. W. HORNER, *Secretary.*

Technical Society of the Pacific Coast.

REGULAR meeting of the Society, held in the Mechanics Institute Board Room, on Friday evening, June 7, 1912, at eight o'clock.

The meeting was called to order by President Loren E. Hunt.

The minutes of the last regular meeting of the Society, held in honor of Past President Dickie, at the Bellevue Hotel, San Francisco, on Saturday evening, May 11, 1912, were read and approved.

The following gentlemen were elected to membership in the Society, the membership dating, in both cases, from June 1, 1912: Mr. Sylvain S. Abrams, civil engineer, San Francisco, and W. W. Hanscom, electrical and mechanical engineer, of San Francisco.

Mr. Harry Larkin read a paper entitled "Development and Increase in the Use of Asphaltum," which was discussed at length by President Hunt, Thomas Morrin and G. Alexander Wright.

Because of the lateness of the hour, the reading and discussion of the paper submitted by Mr. J. H. G. Wolf, entitled "Regulation of Industries by Governmental Supervision," was postponed until the next regular meeting of the Society, to be held in July.

The meeting thereupon adjourned.

OTTO VON GELDERN, *Secretary.*

Oregon Society of Engineers.

PORTLAND, ORE., APRIL 25, 1912. — A special meeting of the Society was held at East Side Library Building, April 25, 1912, at eight o'clock P.M., so that the Society could enjoy a talk by Mr. Ralph Modjeski, of Chicago, on the "Foundations of Bridges over the Willamette and Columbia Rivers, with Special Reference to the Spokane, Portland & Seattle Railway Company Bridges over the Columbia and Willamette Rivers at Portland."

Mr. W. S. Turner, Third Vice-President, presided. There were present about one hundred members and visitors.

On account of the limited time that Mr. Modjeski could be present, the reading of the minutes of the previous meeting was dispensed with.

Mr. Modjeski then described the design and method of construction of the foundations for the above-named bridges, as well as the foundations for the new "Broadway Bridge" over the Willamette at Portland, a full report of which will appear in a later issue of the JOURNAL.

The Society, through Mr. Turner, expressed its deep appreciation of Mr. Modjeski's valuable talk and its regret that Mr. Modjeski, on account of another address elsewhere the same evening, was obliged to cut short his discourse.

Mr. Fowler, representing the Seattle members of the American Society of Civil Engineers, then extended a cordial invitation to the Oregon Society of Engineers to be present at the annual convention of the American Society of Civil Engineers, to be held in Seattle during the last week in June, and asked the Society's coöperation in the entertainment of the visiting engineers.

As there was no further business to come before the Society, the meeting adjourned.

F. A. NARAMORE, *Secretary.*

EXECUTIVE BOARD MEETINGS.

PORTLAND, ORE., MARCH 23, 1912. — At a meeting of the Executive Board held on March 23, 1912, Mr. F. A. Naramore resigned as Treasurer of the Society, and was then elected Secretary to fill out the unexpired term of Mr. J. C. Stevens, who resigned on March 14 on account of his going to Barcelona, Spain, to be engaged on a large hydro-electric and irrigation project there. Mr. Stevens's address is Apartado 491, Barcelona, Spain.

F. A. NARAMORE, *Secretary.*

PORTLAND, ORE., APRIL 6, 1912. — At a meeting of the Executive Board of the Society, held on April 6, 1912, Mr. Gordon Kribs was elected Treasurer of the Society, to fill out the unexpired term of Mr. F. A. Naramore, who resigned on March 23.

F. A. NARAMORE, *Secretary.*

PORTLAND, ORE., MAY 22, 1912. — At a meeting of the Executive Board of the Society, held on May 22, 1912, Mr. J. H. Lewis, state engineer of Oregon, was elected as a member of the Board of fill out the unexpired term of Mr. Frederick Powell, whose resignation was due to his moving to Seattle, Wash., to become consulting engineer for the Seattle Construction and Dry Dock Company.

F. A. NARAMORE, *Secretary.*